RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOLUME XXV.

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RECORDS

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THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1892. [February.

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1891.

The year commenced with the following disposal of the officers of the Survey:—Mr. Foote in the Cuddapah district of Madras; Mr. Hughes, with Dr. Warth, at the tin exploitation in Tenasserim; Mr. Griesbach proceeding to join the Miranzai Expedition on the North West Frontier; Mr. Oldham, with Sub-Assistants Hira Lal and Kishen Singh, at coal and oil in Baluchistan; Mr. Bose at coal and copper in the Darjiling District and Sikkhim; Dr. Nöetling at coal and the demarcation of oil-fields in Upper Burma; Mr. Middlemiss at coal in Hazara, but about to be attached as Geologist with the Black Mountain Expedition; Mr. LaTouche at the exploitation of the Daltongunj coal-field in Bengal; and Mr. Datta at coal in Assam.

Mr. Holland continued at head-quarters in charge of the Museum and Laboratory, in which last, besides the proper research work, considerable endeavour was made to guide the abnormally speculative rush at a development of the gold conditions of Chota Nagpur by numerous assays of reasonably authenticated samples of quartz and other rocks sent to us for determination.

It will thus be seen that the main force of the Department was devoted to economic mineral exploration; though, as the last volume of the published records will show, geological investigation was kept, as much as possible, in parallel working.

PENINSULAR INDIA.

MADRAS PRESIDENCY.—Mr. Foote's retirement from the service at the end of September last has, for a season at least, closed the survey of the great metalliferous series (Dharwars) of Southern India; still, it is eminently satisfactory that, from an economic research point of view, my esteemed colleague has closed his career after a thorough localization of all the important areas of gold and iron occurrence or production in Madras.

Localization of gold tracts finished.

The southerly extension of the Dharwars over the western division of the Cuddapah district was surveyed during the field season, without, however, any further finds having been made of auriferous tracts in that direction.

Just towards the end of the season, and in connection with his visit to the boring for artesian water now being carried out by the Rev. Superior of the Monastery at Place's Gardens, Kilacheri, Chingleput district, Mr. Foote recognized indications in the débris from the bore-hole, which point to no less an important contingency than the existence of a coal-field within 30 miles of Madras. Hitherto, we have only been able to recognize members of the upper division of the Gondwana series in the country south of the Kistna river, though Mr. Foote has all along suspected that a representative of the lower division, or proper coal-bearing series, might underlie the broad alluvial tract of the old Palar river. The boring has now disclosed the fact that the known strata of the locality, which show no trace of carbon, are underlaid by black carbonaceous and bituminous clays, with associated grits and sandstones. So remarkable a difference between the two sets of strata can barely be considered as other than indicating a very decided variation of the circumstances and conditions of formation of the upper group from those prevailing during the deposition of the lower one—which circumstances and conditions, Mr. Foote is led to infer resembled those prevailing in the Lower Gondwana times of the northern part of the peninsula; or, in other words, that there is here hidden away below the Sripermatur beds of Madras a representative of the Indian coal-measures.

Indications of possible coal-fields near Madras.

It is understood that exploration, grounded on Mr. Foote's reading of the evidence brought to light, is about to be instituted under private enterprise, which, as he still remains in India as State Geologist to the Baroda Government, will have the advantage of his watchful advice in its progress. So far, the original boring has reached a depth of 307 feet, and is still in bituminous shale for 25 feet.

Dr. Warth, on transfer from Burma, in August last, was appointed Officiating Superintendent of the Madras Museum; and during his tenure of that office he will keep up a continuance of mineral economic enquiry for the Madras Government until the proper geological survey can be resumed. He has already in this line visited the steatite mines of Betumcherla, in the Kurnool district, in company with me; and the mica mines in the Nellore district with Mr. Holland. The steatite mines which had been decided on by us, and later on by experts in London, as yielding the best stone for the manufacture there of gas-burners, had been reported by the local officials as incapable of yielding blocks of the required sample cube. We found that the thicknesses of the beds are, as a rule, too small to allow of 6-inch cubes; but as there was some cause for assuming that the limit of cube laid down may have been settled at random, considering the small size of the gas-burners, it is possible that the 3 to 4-inch thickness of the "bulpum" beds may not, after trial of the stone sent to England, retard the development of this industry. In any case, a better system of mining than the grubbing work carried on at present will have to be adopted before satisfactory production can be relied on. The opening up of the mica industry at Thakurti, in the Nellore district, is of the greatest importance and interest, as being, I understand, entirely the work of a private explorer and prospector, Mr. Sargent; and because, where I, in my survey of the district some twenty years ago, only saw coarse and irregular crystalline masses of the mineral, the

Kurnool steatite.

Nellore mica development.

largest of which were 4 inches across, the new excavations have yielded great crystals, beautifully clear and without flaws, measuring 2 to 3 feet in diameter and thickness. Additional interest is also attached to this development, as Mr. Holland, in his inspection of the associated rocks, found a splendid specimen of *apatite*, which, if his determination prove correct, is most important, considering the scarcity of that mineral and the rareness of phosphatic sources in India.

. . . . .

BENGAL PRESIDENCY.—The result of Mr. La Touche's examination of the Daltongunj coal-field by survey and by selection of sites for boring, some of which he carried out himself, is, that I have had to condemn the field in so far as its capabilities were expected to warrant the construction of a railway from Daltongunj to Mogulsarai, the initial object of which was the supplying of coal of a superior quality over the system of railways beyond the latter junction station. Mr. La Touche's report was published in Part 3 of the year's Records; but on it I had already summarized as follows, under date the 26th June:—

Daltongunj coal-field exploration: unfavourable results.

"(*a*) The Daltongunj coal-field has an area of about 30 square miles; its strata of sandstone and allied rocks, with seams of coal or carbonaceous shale, are lying in tolerably easy undulations or rolls, although they are at the same time very much cut into and worn away by denudation.

"(*b*) Practically and for all purposes of estimation as to the value of the field, there are only two seams of coal worthy of consideration.

"(*c*) The first or upper seam of coal is very variable in thickness (from 1′ 6″ to 7′ 6″), so much so indeed that any estimate formed as to the total quantity of coal contained within the area of the borings (and these were selected on the best ground) would be unreliable. The coal of this seam is generally very shaly; this appears to be the seam which was worked by Messrs. Hodges and Radford at Singra; it may be called the Singra seam.

"(*d*) The second or lower seam is also very variable, but is generally thicker than the first, running (with variations) from 29 feet to 6 feet in its best development. This is the seam in which the pits belonging to the Bengal Coal Company were formerly worked: it may be called the Pundua seam. It is even difficult here to form a fair estimate of the quantity of coal; but assuming that the thickness of coal in this seam, over an area of one square mile east of Rajhera, is 9 feet, Mr. La Touche reckons that it would furnish a total quantity in round numbers of 9,000,000 tons Here also the coal is often very shaly.

"(*e*) The more promising boring samples of coal give poor assays: they show, in fact, that the coal is of an inferior kind. (Mr. La Touche does indeed suggest that a fairer estimate of the constitution of the coal should be obtained by trial in bulk, but, as will be seen later on, I question the worth of such a trial.)

"(*f*) The evidence obtained of lower seams than the Pundua seam does not appear to justify any expectation of better coal on a large scale.

"Comparing these results with the previous estimate of Dr. Saise, of a total quantity of not less than 161,377,000 tons of coal containing 11·7 per cent. of ash, and the original estimates of Mr. Theo. Hughes of the Geological Survey, *viz.*, 11,600,000 tons of available coal with, say, 10 to 13 per cent. of ash; and considering that Messrs. Hughes and La Touche are experts in the recognition of strata associated with coal seams in the Indian coal-measures and at following these up or in reasoning as to how they may be expected to continue underground, I have, after careful consideration of the evidences, formed the following conclusion.

"I think this boring exploitation may be taken as conclusive, regarding the inadequacy of the Daltongunj coal-field for meeting the demand required for the proposed railway; although it offers every prospect of meeting local and not very distant demands for fuel.

"Neither the estimated available tonnage, nor the quality of the coal, have been found to improve on those originally ascertained by Mr. Hughes; although I had all along hoped that more detailed examinations and borings might have shown that he was too prone to keep his estimates very well within reasonable probabilities. Mr. La Touche's estimate is, of course, only made on a good area of medium thickness coal; but although it could be easily run up to that of Mr. Hughes, I regret that the data before the Geological Survey do not justify our venturing anywhere near Dr. Saise's so much more favourable estimate.

"Mr. La Touche's boring assays are certainly very depressing in their ash percentage: but as I myself have had considerable experience in the Chhattisgarh fields, which, in many respects are like this Daltongunj tract, where the boring samples, notwithstanding my fears of their being mixed with shale, did after all give assays which differed very little from the assays of the coal from trial pits; I therefore do not think that testing in bulk, as suggested by Mr. La Touche, would show any very appreciable improvement in the power of the coal."

The Darjiling coal exploration was continued to the west of the Lisu-Ramthi area surveyed by Mr. Bose during the previous year. The entire Lower Gondwana or Damuda area between Pankhabari and the Tista was examined in some detail, and special attention was paid to the ground just by the Tista Valley cart-road, but the excavations disclosed no promising seams: thus the question of the probable existence of workable seams in this particular area may now be considered as settled.

Darjiling coal survey finished.

The well-known Tindaria outcrops on the Darjiling Railway are in this area and were reported on years ago by Mr. Mallet, though not without considerable doubt as to their ultimate successful development. Mr. Bose does not offer any more encouraging data: indeed he seems to imply that the condition of the coal itself and its mode of occurrence are even more against the working of it than Mr. Mallet was inclined to argue.

Opportunity offering, at the close of this coal exploration, for some further examination of the copper occurrences in Sikkhim, Mr. Bose was posted to this work. He examined sixteen ore localities: only two of these were being worked at the time of his visit, the abandonment of six other places being attributable to the inability of the miners to deal with the influx of water after excavating only to a very moderate depth. Nine ore localities are described as not having been tried at all.

Copper occurrences in Sikkhim; fairly promising.

The mines, or rather burrowings, at Tuk, Bhotang, Ratho and Pachi, appear to be certainly the most promising in all Sikkhim. Mr. Bose thinks that deep mining on modern methods is likely to yield a very fair return at Pachikhani and Rathokhani, where the miners are now at work; and even at the abandoned workings at Tukkhani and Bhotangkhani. It is, of course, questionable whether development in such a distant region, under European enterprise and management, would be a success; but there seems little doubt that a surer prospect of paying return may be anticipated under a more economical and smaller staff of western management and labour than is usually considered necessary in Indian mining ventures, supplemented by reliable trained country labour. I am the more earnest on this point, considering how admirably and successfully such a system was being followed out by Ritter von Schwartz during his management of the Government Iron Works at Barrakar; while I believe that Dr. Saise, of the East Indian Railway Co's. coal-fields at Kurhurbari, has also had satisfactory experience of the adaptability of country labour to more responsible work.

Be this as it may, Mr. Bose writes of the four ore localities mentioned above, that Pachikhani appeared to him the most promising, as the existence of at least one rich deposit is known, and that it ought to be tried first in case Sikkhim should attract mining enterprise. A sample, taken at random from the deposit mentioned, yielded 31 per cent of copper; and from what the miners told him, the average yield from the entire mine is about 12 per cent., or 5 seers of copper from one maund of ore. Tukkhani, he thinks, would be a very favourable place for trial after Pachikhani. Mr. Bose's reports on the Continuation of the Darjiling Coal Exploration, and on the Geology and Mineral Resources of Sikkhim were published in the fourth part of the year's volume of the Records.

EXTRA-PENINSULAR INDIA.

Renewed survey of Garo Hills coal: no better results at Goalpara and Rongrengiri.

ASSAM.—Renewed enquiry having been made by the Chief Commissioner of Assam concerning the coal occurrences in the Garo Hills;—and notwithstanding that these places had been visited many years ago, in the first instance, by Mr. Medlicott, and later still by Mr. La Touche, I thought it advisable on several grounds to post Mr. Datta at this work. His attention was first given to the coal indications on the North-West Frontier, in the Goalpara district, close to Singmari on the old Bramaputra. In 1868 Mr. Medlicott reported that "the existence of a fair seam of useful coal at Siju was confirmed, the then value of it being questionable on account of difficulty of access from the plains, across some 10 miles of low, rugged, hills. Of all the known outcrops at Mirampara and Champagiri, a most unfavourable account had to be given: the deposit was indeed the same as at Siju, and more favourably circumstanced for working, the measures being quite horizontal, and close to the surface, but the seam contained only a few irregular little strings of coal in a thick bed of clay, resting almost directly upon a platform of gneissic rocks. The only apparent useful coal there lay in a possible development of the deposit on the same horizon to the deep of the formation in its main basin, on the south of the barrier of crystalline rocks; and I suggested that this point might be determined by a boring in the neighbourhood of Harigaon."

This report of Mr. Medlicott would, on the face of its being the result of so experienced an observer's survey, appear to be a sufficiently exhaustive expression of the poor look-out of the field, except in the direction of Siju; but the now increasing tendency of certain firms of the mercantile community of Calcutta to utilize coal areas adjacent to their planting properties in Assam, seemed to demand such further evidence as could be obtained, especially with regard to this region, and again on the higher country in the neighbourhood of Tura. As was to be expected, Mr. Datta's examination of the first tract only resulted in some further information as to the geological formations and the finding of more outcrops of the same thin coals or carbonaceous shales.

In the Rongrengiri field, he had again to go over ground concerning which Mr. Medlicott had written as follows :—"Some miles up the valley of the Semsang to the west, there is another considerable basin of the coal-measure rocks, occupying the valley above and below the Rongrengiri outpost for a direct distance of seven miles. Locally it is five miles wide. I could nowhere find an outcrop of the coal within this area; but there are stratigraphical features suggesting that it may exist within

the basin at greater depths than the present surface." At a very much later date, Mr. La Touche failed to discover coal seams of any practical value, though he noticed a seam of good coal, one foot thick in a hill, due east of Shemshangiri, and there are several outcrops of a bed of carbonaceous shale, about 3 feet thick, at the west end of the field, which he considered to represent the principal seam of the Darangiri coal-field. Mr. Datta has now furnished a report, in which he adds three outcrops to that mentioned by Mr. La Touche, the thickest being only 18 inches; though on this, he tries to make the very best of a supposition that one seam, averaging 1 foot 3 inches in thickness, may be continuous over 10 square miles. It is with great regret that I am unable to follow him in this estimate: indeed, were the seam tolerably continuous with such a thickness, it is very questionable whether it could be worked, even were the locality less difficult of approach than it is. As a matter of previous survey, the proper and only field in this region offering immediate prospect of successful development is that of Darangiri; for which, too, an application for prospecting and ultimate leasing has been for some time before the Government.

Darangiri, the proper field.

BALUCHISTAN.—The survey for coal and oil having extended over all the country within convenient reach of the railway lines, and in some parts much beyond that, Mr. Oldham's party was withdrawn at the end of the working season. His season commenced by his catching up the Kidderzai field force at Dhanasar, with the object of examining the reported oil occurrence at Kot Moghul, about 13 miles south-east of the Takht-i-Suleiman. Mr. Oldham's condition of health, after an almost continuous field working of eighteen months, prevented his meeting Sir R. Sandeman at Apozai, as had been previously arranged, though he tried his best to do so, and in the end he was only able to establish the bare fact that there is a small outflow of oil. He reported it as of excellent quality, but this estimate was found to be too favourable when the oil was subjected to laboratory judgment. The question of whether the oil existed in sufficient quantity in the strata, or whether it could be more favourably tapped than at the present place of natural issue, could not be determined without a more extensive survey than was then possible; and the carrying out of that will be a troublesome operation, considering that the country is a tribal region on the frontier of the Punjab.

Kot-Moghul oil, on Punjab frontier.

The history of this enquiry, so far, has been given in the second part of the year's volume of the Survey Records, by Mr. Oldham himself, and by Mr. Holland for the laboratory investigation; and it may be as well to summarize it here. In December 1889 a sample, stated to be raw mineral oil, was forwarded to me at the instigation of His Excellency the Commander-in-Chief. This was examined by Mr. Lake in our laboratory and found to have a density of 0·822, and a flashing point of 89° F., which result aroused our suspicions as to the reported source of the oil. Dr. Warden, Chemical Examiner to the Bengal Government, found the specimen submitted to him to have a specific gravity of 0·8209 at 15·5° C., and a flashing point of 89° F.; and he concluded that the specimen was not a crude oil, but a commercial kerosine oil of Russian origin. In September 1890 Dr. Warden reported on a further specimen, procured by the Deputy Commissioner of Dera Ismail Khan, when he found it to have a specific gravity of 0·8154 at 15·5° C. and a flashing point of 84·29° F.

Mr. Oldham was then instructed to visit the locality and send down samples, which, when tried in the laboratory, yielded results showing it to be decidedly inferior in quality, as compared with the other samples.

It has now been decided, in communication with the Dera Ismail Khan authorities, that as soon as arrangements for visiting the country can be settled, a thorough examination of the stratigraphical conditions of the country shall be made with a view to determining the probable underground storage of the oil and the chances of tapping a larger issue by boring.

Mr. Oldham's further work in Baluchistan enabled him to send in reports on an outflow of petroleum in the Robdar Valley, Bolan Pass; on the petroleum resources of the country adjoining the routes to Quetta; and on the coal resources of Quetta and the routes leading to it; while his increased experience of the general stratigraphy of the country conduced to his adding some further evidence in favour of Mr. Medlicott's original suggestion in 1886 for a speculative trial boring near Rohri, on the Indus. As a move in that direction, I have just, at the close of the year, selected places near to and within the North Western Railway works at Sukkur, in view of projected boring operations.

Fuel Conference at Quetta.

In this connection, I attended the Conference on Fuel at Quetta early in December last, when Mr. Oldham's views on the oil conditions of the Khattan field and in the Spintangi Valley were discussed. The test boring recommended by him for the final settlement of the prospects of the Khattan tract is being carried out; but this finality of procedure was very naturally disputed by Sir R. Sandeman, who discovered this oil tract, and by Mr. Townsend, who had superintended all the oil exploitations in Baluchistan until within the last six months. The latter gentleman still relies on certain state breaks or faults in the neighbourhood of Khattan, on the further side of which he considers there is a possibility of oil. Under the circumstances, and feeling that no chance should be allowed to pass of disclosing a larger and freeer issue of oil than has been met with hitherto at this place, I volunteered, notwithstanding the fact that Mr. Oldham's map showed no sign of any marked faulting, to personally examine Mr. Townsend's stated condition of the stratigraphy should the boring now being put down turn out unfavourable to the future of the field. It was also resolved at this Conference, Mr. Townsend and I being in agreement, that a new boring should be put down on the Sind-Pishin Railway, in the Chuppar Rift.

Further report on the Kalka coal: shows unfavourable results.

NORTH-WEST PROVINCES.—The existence of very thin strings of coal and carbonaceous shale at Kalka, in the Simla district, has been known to the Survey for very many years, but the extension of railway communication to that place has naturally aroused renewed speculation as to the value of some lately reported finds; and urgent enquiry was made by the Deputy Commissioner of Simla. Mr. Griesbach examined the country in October, upon which he reports that none of the coal deposits seems to be of any importance. The best exposure is near Kalka, in the valley of the Kassaulia stream, about one and a half miles up-stream from Tipra village and one mile west-south-west from Datiar Chouki on the Simla-Kalka road. The only coal trace in this exposure which might attract notice is an irregular deposit

splitting up into seams, separated by a lenticular bed of sandstone of about 6 inches in thickness. The seam may be estimated as having an average thickness of from 2 to 3 inches, but at one point it is seen to expand to from 8 to 12 inches. The quality of the coal is good enough, and it burns freely, but there is not enough of it to warrant working. Similar traces, all lignite, are found at several localities in the Kalka neighbourhood, and in the Nahan division of the Siwalik formation, but none of them indicate any increase on the estimate formed on the Kassaulia exposure..

BURMA.—The tin exploitation in Tenasserim, under Mr. Hughes, was continued with satisfactory result; a very strong outcrop of the ore-bearing rock itself having been defined within the Maliwun township, from which very encouraging samples of tinstone were obtained. The importance of this find may be gauged when it is considered that this rather abnormal form of lode occurs in the series of rocks constituting the ridges of the country, from the denudation of which the stanniferous alluviums of the valleys have been formed, and that it can hardly be the only good lode of the kind. A considerable part of this lode is so decomposed or weathered as to be sluiceable with profit. The existence of rich alluvial deposits in the Maliwun district is also certain, though they and the rocky zone are not, I fear, rich enough to pay working under, as I have already remarked in connection with copper mining in Sikkhim, elaborate European management and working. The venture must be made under an improved system and encouragement of Chinese working similar to that ruling in the Straits Settlements; and it is satisfactory to note that the labours of Mr. Hughes and his party of prospectors have yielded results which have brought forward applications from syndicates, experienced in that field of operation, for the prospecting and ultimate leasing out of lands in the Maliwun tract. In summarizing the results of the exploitation up to the end of last season's prospecting, Mr. Hughes also considers that he is justified in saying that the alluvial tin in Bahuni, Karathur and Plyngan is of good quality, and such as should yield good returns if worked under fair conditions; meaning, by fair conditions, sufficient means on the part of those who would start work, and readiness on the part of the Local Administration to assist them heartily by carrying out necessary measures.

Tin exploration in Mergui: very satisfactory progress.

Much remains to be done in prospecting so large and trackless a region, but I think that by the end of the present season sufficient will have been accomplished, by the Survey of India in topographical surveying, and by ourselves in the demarcation of good tin areas, for the furtherance of a successful tin development by private enterprise.

In Upper Burma, Dr. Nöetling's services have been fully, and, as I understood in personal conference with the Financial Commissioner of Burma, most advantageously employed, not only in the demarcation of the oil-fields, but in the definition of the State wells, and settlement of the rights and position of the Twinzas, or old native miners. At the same time, he has prepared a very elaborate and full memoir on the history and working of the oil-fields, for the Government of Burma.

Upper Burma oil-fields.

In view of the extension of a railway to Myingyan, a reconnaissance of the country was made in that direction in the way of prospecting for coal, but without finding outcrops; the result showing that even if the group of coal-bearing rocks

Myingyan coal prospects.

on the eastern side of the Irrawaddi valley does exist on the Myingyan side, it would lie at too prohibitive a depth for working. Towards the close of the year, Dr. Nöetling was despatched to explore the jade and amber tract, being attached to the Column proceeding to Northern Upper Burma. His work in this direction will be good, considering that a portion of his earlier career in Europe was spent at amber mines.

South India: North-West Frontier of Punjab: and Sikkhim Himalaya.

GEOLOGICAL INVESTIGATION.—*Crystalline and Transition Series.*—The season's surveying in the Madras Presidency completed the examination of the larger and more prominent tracts of the Dharwar Series, with their associated older schistose gneisses and granitoids occurring in the very extensive tract of country included in the districts of Anantapur, Bellary, Cuddapah, and Kurnool. This great area, hitherto displayed on our geological map of India as a gneissic region, is therefore now capable of being brought into much nearer formational correlation with Central India and the western frontier of Bengal, where certain groups of transition rocks—notably the 'Gwaliors,' and possibly the 'Bijawars' also—occur as prominent ore-bearing formations. The Madras crystallines, as more recently worked out by Mr. Foote, also appear to have much in common with the Bundelkhund gneiss, as well as that of Bengal. This advance in our knowledge of Madras geology will therefore be of distinct value in the new edition of the Manual of the Geology of India, and its accompanying map, now being written by Mr. R. D. Oldham. The more detailed memoir by Mr. Foote is now in press.

In the far distant North-West Frontier, the deputation of Mr. Griesbach with the Miranzai Expedittion, and Mr. Middlemiss with the Black Mountain Force, have afforded only slight opportunities of studying the crystallines (igneous and metamorphic) in that direction. Mr. Griesbach's work is embodied in a paper on the geology of the Safed Koh, which will shortly be published.

From the North-East Himalayas, we have useful notes by Mr. Bose on the elevation and disturbance of the Sikkim Himalaya, and on the igneous rocks of Darjiling and Sikkim. The former seems to be a pretty direct application of the general results obtained by Mr. Medlicott and Mr. Middlemiss in the Sub Himalaya of the North-Western Provinces.

Baluchistan: and Hazara.

Cretaceous, Tertiary, and Recent.—From Baluchistan, Mr. Oldham has sent in reports on the recent deposits of the valley plains of Quetta, Pishin, and the Dasht-i-Bedaolat; on the geology of the Thal Chotiali and part of the Mari country; on the geology of the country west of the Bolan Pass; and on a tour from Quetta by Kach to Ziarat, Hindubagh.

The second of these papers is of special interest as adding a further link to the evidence already gained in peninsular India and Sind, pointing to the occurrence of passage beds which appear to have been deposited during the time interval represented by the gap between the Secondary and Tertiary periods in Europe. Extended survey of the stratigraphical groups already distinguished by Mr. Oldham has shown that his Dunghan group is not only separated from the cretaceous "belemnite beds" below by a slight though distinct unconformable break, unaccompanied by disturbance; but that, while it is an essentially limestone group of great

thickness in the northern part of the area and in the Harnai district, it becomes, to the south-east, an argillaceous one, with only an attenuated limestone facies in its uppermost beds. But with this change, it becomes abundantly fossiliferous, with a fauna having cretaceous and yet decidedly nummulitic affinities. The author is sufficiently guarded in his reading of the unconformability, the change of lithological facies, and the anomalousness of the fauna; but these conditions are fairly open to the interpretation that the Dunghan group probably represents the gap stated above. Mr. Oldham's paper is issued with the current records.

His article on the recent deposits of the valley plains is also published, a feature of interest in it being a discussion of the native "karez" system of tapping water sources at the foot of the flanking hills, and leading it by underground tunnels, or *kareses*, to the lower levels of cultivation. It also treats of the remarkable group of natural artesian springs at Quetta itself; from the study of which and the other conditions of the valley plains the author prepared a note for the Baluchistan Agency on the mode of occurrence and probable distribution of artesian water in the Quetta and Pishin districts.

In Hazara, Mr. Middlemiss's work, early in the season, lay among the lower ranges of hills immediately north of the Rawalpindi plateau, especially along the base of the nummulitic stage, in search of any extension of the Abbottabad coal band, of which however he found no further traces.

A notable feature connected with the recent geology of Hazara is the presence of thick banks of coarse gravel at Diliari and other places, at a height of about 2,000 feet above the level of the Indus. These gravels differ in no way from the beds of gravel at present deposited by that river; and they indicate that combined upheaval of the country and deep cutting of the Indus have resulted in separating the present and past erosion planes of that river by this enormous vertical distance.

Palæontological.—Professor Waagen has been our chief worker. The second part of his *Geological Results*, arising out of his elaborate study of the palæozoic Salt Range fauna, was published early in the year. He continues working at the *Ceratites*, some 20 plates of which are already stored in Calcutta, in readiness for the illustration of the text descriptions.

It hardly becomes me to write in praise of this latest contribution from so distinguished a savant as Dr. Waagen, for it will, indeed has received its meed, in that respect, from the most competent judges in the palæontological world; but the latest testimony I have before me is that his generalizations on the correlation of the Salt Range palæozoics with those of other regions have received remarkable confirmation in the recognition by Oberbergrath Mojsisovics of a Salt Range and Australian faunæ in the collection of carboniferous fossils obtained by the Survey in the North-West Himalaya.

The lamentable death of Professor P. M. Duncan necessitated the transfer of the collections of Kach jurassic *echinoids* and *corals* sent home to him for description, to some other specialist in this section of research;—a contingency for which Dr. Duncan had, as it turned out, thoughtfully provided for by asking Mr. J. W. Gregory, of the Natural History Department of the British Museum, to undertake the work. This arrangement was then confirmed by Dr. Henry Woodward; and we have just received Mr. Gregory's fasciculus on the ECHINOIDEA.

Arrangements have also been made, under the kind guidance of Professor Ed.

Suess of the Imperial University of Vienna, for the study and description of our Himalayan collections by specialists in Austria: Palæozoics, by Dr. Wentzel; Triassics by Oberbergrath Mojsisovics; Rhoëtics, by Dr. Bittner; and Jurassics (Spiti), by Professor Uhlig. In the progress of study so far, Professor Suess reports that our Silurian fossils are rather poor. On the other hand, the very remarkable though not unforeshadowed feature has been recognized, that the carboniferous fossils belong to two very different faunæ, one of the Salt Range type and the other related to Australian carboniferous. The triassic fossils, again, are of such extreme interest as to have induced Professor Suess, in conference with Mojsisovics, to propose the sending out of Privat Docent Dr. Dienêr, under contributions from the Boué Fund and the Academy of Sciences, for the further collection of fossils, in concert with the Survey, considering, as he does, that "Griesbach's discoveries are so important that it seems well nigh our duty to follow them up as far as we possibly can." Such an implied appreciation of the survey work in Himalayan geology is naturally most gratifying to us; and we too are bound to meet this most liberal and distinguished proposal in as helpful a spirit as can be accorded to us by the Government of India.

Museum and Laboratory.—Mr. Holland is selecting and arranging mineral specimens, models, and drawings to form a collection as an introduction to the study of mineralogy, which will be employed also to illustrate the demonstrations proposed to be given to the students of the Presidency College. Considerable progress has been made towards a more complete arrangement and classification of the rock collection.

The work in the Museum, however, has been considerably delayed on account of the increase in the number of specimens received in the laboratory for determination and analysis. The principal ores assayed during the year were those of gold, silver, lead, tin, copper, and iron; in addition to samples of coal, coke, crude mineral oils, and brines.

Mr. Middlemiss's paper on the Salt Range geology (Records, Vol. XXIII, page 19), published in the beginning of the year, besides adding much of importance to our knowledge of that area, shows that we are not as yet in possession of sufficient data for the satisfactory solution of problems connected with the remarkable position and characteristics of the salt-marl and its associated minerals. As an initial move in the way of solving the questions raised, Mr. Holland has devoted a portion of his leisure to the closer study of rocks collected in this region; and he informs me that the results obtained so far throw considerable light on the local problems besides adding much of general mineralogical interest. Among these may be mentioned the discovery of large proportions of *anhydrite* in the bi-pyramidal quartz crystals ("Mari diamonds"); the occurrence also of anhydrite in the hard nodules of the gypsum beds, and the stages in the process of hydration, with the interesting structures produced during the crystallization of the latter and its intergrowth around fragmentary remains of anhydrite-crystals. The structures produced in these rocks by movements in the mass are also worthy of remark; the gliding planes in the crushed anhydrites and the bent lamellar twinning of the gypsum, passing into stages in which inequiaxed fragments have, by the forced assumption of parallelism, given rise to examples of the most perfect schistosity. Mr Holland concludes that the *data* so obtained offer some

List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1891.

ADELAIDE.—Royal Society of South Australia.
ALBANY.—New York State Museum.
ALLAHABAD.—North-Western Provinces and Oudh Provincial Museum.
BALLARAT.—School of Mines.
BALTIMORE.—Johns Hopkins' University.
BASEL.—Natural History Society.
BATAVIA.—Batavian Society of Arts and Sciences.
BELFAST.—Natural History and Philosophical Society.
BERLIN.—German Geological Society.
„ Königlich Preussische Geologische Landesanstalt.
„ Royal Prussian Academy of Science.
„ Royal Prussian Geological Institute.
BOLOGNA.—Royal Academy of Sciences.
BOMBAY.—Bombay Branch of the Royal Asiatic Society.
„ Marine Survey of India.
„ Meteorological Department.
„ Natural History Society.
BORDEAUX.—Linnean Society of Bordeaux.
BOSTON.—American Academy of Arts and Sciences.
„ Society of Natural History.
BRESLAU.—Silesian Society.
BRISBANE.—Queensland Branch, Royal Geographical Society of Australasia.
„ Queensland Museum.
BRISTOL.—Bristol Naturalists' Society.
BRUSSELS.—Royal Geographical Society of Belgium.
„ Royal Malacological Society of Belgium.
BUDAPEST.—Hungarian National Museum.
BUENOS AIRES.—Argentine Republic.
CAEN.—Linnean Society of Normandy.
CALCUTTA.—Archæological Survey.
„ Asiatic Society of Bengal.
„ Editor, "The Indian Engineer."
„ „ "Indian Engineering."
„ Indian Association for the Cultivation of Science.
„ Indian Museum.
„ Meteorological Department, Government of India.
„ Survey of India.
„ University of Calcutta.
CAMBRIDGE.—Philosophical Society.
CAMBRIDGE, MASS.—Museum of Comparative Zoölogy.
CASSEL.—Royal Mineralogy (Geology) and Pre-Historic Museum of Dresden.

CHRISTIANIA.—Editorial Committee, Norwegian North Atlantic Expedition.
CINCINNATI.—Society of Natural History.
COPENHAGEN.—Royal Danish Academy.
DEHRA DUN.—Great Trigonometrical Survey.
DRESDEN.—Isis Society.
DUBLIN.—Royal Dublin Society.
„ Royal Irish Academy.
EDINBURGH.—Geological Society.
„ Royal Scottish Society of Arts.
„ Royal Society.
„ Scottish Geographical Society.
„ Signet Library.
FLORENCE.—Royal Geological Commission, Italy.
GENEVA.—Société de Physique.
GLASGOW.—Geological Society.
„ Glasgow University.
GOTHA.—Editor, Petermann's Geographische Mittheilungen.
GÖTTINGEN.—Royal Society.
HALLE.—Kais, Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher.
HARRISBURG.—Geological Survey of Pennsylvania.
HOBART.—Royal Society of Tasmania.
KÖNIGSBERG.—Physikalisch-Ökonomische Gesellschaft.
LAUSANNE.—Vandois Society of Natural Sciences.
LEIDEN.—École Polytechnique de Delft.
LEIPZIG.—Vereinfür Erdkunde (Geog. Society).
LIEGE.—Geological Society of Belgium.
LISBON.—Geological Survey of Portugal.
LIVERPOOL.—Geological Society.
LONDON.—British Museum (Natural History).
„ Geological Society.
„ Iron and Steel Institute.
„ Linnean Society of London.
„ Royal Geographical Society.
„ Royal Institute of Great Britain.
„ Royal Society.
„ Society of Arts.
„ Zoological Society.
MADRAS.—Forest Department.
MADRID.—Geographical Society.
MANCHESTER.—Geological Society.
„ Literary and Philosophical Society.
MELBOURNE.—Department of Mines and Water-Supply, Victoria.
„ Premier, Natural History, Victoria.
MILANO.—Italian Society of Natural Sciences.
MONTREAL AND OTTAWA.—Geological and Natural History Survey of Canada.

MONTREAL AND OTTAWA.—Royal Society of Canada.
MOSCOW.—Imperial Society of Naturalists.
MUNICH.—Royal Bavarian Academy.
NAPLES.—Royal Academy of Science.
NEWCASTLE-ON-TYNE.—North of England Institute of Mining and Mechanical Engineers.
NEW HAVEN.—Connecticut Academy of Sciences.
" The Editor of the "American Journal of Science."
NEW YORK.—Academy of Sciences.
OXFORD.—University Museum.
PARIS.—Geographical Society.
" Geological Society of France.
" Geological Survey of France.
" Mining Department.
PHILADELPHIA.—Academy of Natural Sciences.
" American Philosophical Society.
" Franklin Institute.
PISA.—Society of Natural Sciences, Tuscany.
QUEBEC.—Literary and Historical Society.
RIO-DE-JANEIRO.—National Museum.
ROME.—Geological Survey of Italy.
" Royal Academy.
SACRAMENTO.—Californian State Mining Bureau.
SAINT PETERSBURG.—Geological Commission of the Russian Empire.
" Imperial Academy of Sciences.
SALEM.—American Association for the Advancement of Science.
" Essex Institute.
SAN FRANCISCO.—Californian Academy of Sciences.
SINGAPORE.—Straits Branch, Royal Asiatic Society.
STRASBURG.—Strasburg University.
SYDNEY.—Australian Museum.
" Department of Mines, New South Wales.
" Geological Survey of New South Wales.
" Linnean Society of New South Wales.
" Royal Society of New South Wales.
TOKYO.—Asiatic Society of Japan.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
VENICE.—Royal Institute of Science.
VIENNA.—Imperial Geological Institute.
" Imperial Natural History Museum.
" K. K. Geographischen Gesellschaft.
" Royal Academy of Science.
WASHINGTON.—Smithsonian Institution.
" United States Department of Agriculture.
" United States Geological Survey.
" United States Mint.

WASHINGTON.—United States National Museum.
WELLINGTON.—Colonial Museum and Geological Survey of New Zealand.
,, Department of Mines, New Zealand.
,, New Zealand Institute.
YOKOHAMA.—German Naturalists' Society.
,, Seismological Society of Japan.
YORK.—Yorkshire Philosophical Society.
The Governments of Bombay, India, Madras, North-Western Provinces and Oudh, and Punjab.
The Chief Commissioner of Burma.
The Resident at Hyderabad.

Report *on the* Geology *of* Thal Chotiáli *and part of the* Mari country, *by* R. D. OLDHAM, A.R.S.M., F.G.S., *Deputy Superintendent, Geological Survey of India.* (With a map and 5 plates.)

Area to be described.

The area to be described in the following paper lies to the east of that treated of last year; its limits can be seen by reference to the map annexed.

Previous literature.

Apart from the very brief mention of the gorge at Tung by Dr. Blanford,[1] and some papers regarding the petroleum at Khattan which have been referred to in my previous report,[2] there is no literature regarding the area under description.

Structure.
Absence of great faults.

The structure presents the same features as were noticed before, in the almost complete absence of any of those great reversed faults and thrust planes which are so common in mountain regions. The only exception is in the south-east corner, where, according to Sub-Assistant Hira Lal, the upper nummulitic beds and cretaceous beds are faulted into direct contact with each other. But, though not exhibited on a large scale, there are many very pretty instances of faults on a small scale, two of which are shown in Plates I and II.

Horizontal beds.

A very remarkable occurrence of horizontal beds over a considerable area in the Béji valley was quite unexpected in a region usually so highly disturbed. The horizontality is made very conspicuous in the field, and easily recognizable on the map, by the capping of hard Spintangi limestones crowning the hills of Gházij shales and exhibiting those long horizontal lines of cliff and talus slopes, with an irregular outline cut by numerous re-entering angles, which form the scenery characteristic of a deeply eroded series of horizontal beds of unequal hardness.

Stratigraphy.
Oldest rock seen: massive limestone.

The oldest rock exposed is the same grey limestone as was seen in the Miráb Tangi,[3] but it was much better seen this year in the hills west of the Thal Chotiali plain, which are traversed by the Sémbar pass. The beds are thrown into an anticlinal fold, whose core, composed of these hard grey limestones, stands up as a high hill, traversed by the deep gorge of the Sémbar pass.

This gorge is not of the ordinary type of water-worn ravine, exhibiting on either side a section of the beds through which it is cut, but has been formed along a deep and sharply-folded synclinal flexture, which obliquely traverses the main anticlinal. The stream has taken advantage of the narrow strip of soft beds, which was thus made to traverse the hard limestone core, and has deprived us of the deep cut section which this pass should otherwise have exhibited.

About 3 miles to the west, however, there is a gorge cut through a lower part of the hill which exposes a section of a portion of the limestone, and exhibits it as very similar in type to the cretaceous grey limestones of the Quetta hills, with which I have little doubt that it is identical.

[1] Mem., Geol. Surv., Ind., XX, p. 197.
[2] Rec., Geol. Surv., Ind., XXII, p. 93.
[3] Rec. Geol. Surv. Ind., XXII, p. 93; the word 'nummulitic' in the marginal reference is an error.

Distribution.

This limestone crops out in the centre of the Dunghan mountain, of the anticlinals of Samach, of the Miri hill, and of Mazár Drik in the Béji valley. Though not mapped as occurring in the Rastaráni hill, east of Mámand, it appears to occur there, so far as can be judged from the account of Sub-Assistant Hira Lal.

Fossils.

From none of these last named localities were any fossils obtained, but in the Sémbar pass the uppermost beds yielded some fossils, among which a *Rhynconella* was most abundant. A fragment of an ammonite was also found, and *Belemnites*, which appeared to belong to the same species as occurred in the next succeeding group, but they had been shattered by the disturbance the beds had undergone, and could only be extracted in a fragmentary condition which precludes any specific determination.

Belemnite beds.

The massive cretaceous limestones are overlaid with perfect conformity by a series of beds which, in the Sémbar pass, attains a thickness of at least 1,000 feet, but is usually much thinner, the difference being apparently due principally to a squeezing out of the lower shaly beds by compression. In the Sémbar pass the lower half of the group is composed of black shales with some sandy and calcareous beds and, near their base, the shales contain an admixture of volcanic ash. The upper half of the group consists of distinctly bedded green and purple indurated marls and limestones, capped by about 250 feet of compact white limestone.

Equivalent to Chappar shales.

These upper beds resemble so closely, in lithological character, those variegated beds seen in the Chappar rift, which were formerly[1] referred to by me as the Chappar shales, that I have no hesitation in identifying the two. They agree, moreover, in stratigraphical position, as will be seen further on, and the occurrence of an admixture of volcanic ash with the sedimentary material of the lower beds in the Tarai Tangi[2] is another fact pointing to the same conclusion; moreover, there are frequent exposures of precisely similar beds occupying the same position relative to the other rock groups in the ground intervening between the Sembar pass and the Chappar rift.

Having established the identity of the group in the two separate localities, it appears inconvenient that it should retain a name derived from a locality where it is very imperfectly exposed, neither the thick white limestone at the top, nor the still thicker black shales at the base being represented, except in a most imperfect manner, and I shall in future refer to the group as the 'belemnite beds.'

Fossils, belemnites, ammonites.

These belemnite beds are, in many places, abundantly fossiliferous, but the fossils found are almost entirely confined to several species of *Belemnites*, mostly belonging to the section *Dilatati*, the only exceptions being a few fragmentary casts of *Ammonites* found 3 miles west of the Sembar pass.

Nummulites.

The uppermost white limestone was not observed to be fossiliferous within the area of the map, except for a few belemnites near its base, but I have seen it, on the road from Harnai to Loralai, containing both *Nummulina* and *Alveolina*. At the time I was not aware of the true stratigraphical relations of the rock, and, being inclined to class it with the overlying

[1] Rec., Geol. Surv., Ind., XXIII, 93 (1890).
[2] *loc. cit.*, p. 94.

Dunghan limestone, then regarded as nummulitic, did not attach the importance to the observation which it has since proved to possess, and, unfortunately, did not carry off any specimens. There can, however, be no doubt as to the accuracy of the observation.

Distribution.

The distribution of the belemnite beds is wider than that of the underlying massive limestone. Besides forming an oval round all the exposures of the latter, it is the lowest rock exposed in the Sonári anticlinal and in two others in the south-east corner of the map; to the north of Lat. 30° it is the lowest rock seen in the cores of the anticlinals; and is known to be largely exposed to the north of the map in the direction of the Bóri valley.

The distribution of fossils in this group appears, at first sight, to be capricious, for they have only been found in the Sémbar, Samach, Mazár Drik, Dunghan and Miri anticlinals, and not in those to the north-west or south-east of these. This is, however, probably due to the fact that, in those exposures where no fossils have been found, only the uppermost beds are exposed, and these are everywhere very sparingly fossiliferous, if fossiliferous at all. Further to the north, along the Bóri-Mékhtar road, belemnites are common enough in the beds of this group.

Unconformable break.

The belemnite beds form the uppermost member of a conformable system, above which comes a slight, but distinct, unconformable break. This is best seen in the Sonári anticlinal and that near Mazár Drik in the Béji valley, where the beds immediately overlying the white limestone contain numerous fragments of it; in the Mazár Drik anticlinal the white limestone is worn into an undulating surface, on which the lowest bed of the next succeeding system is deposited, and in the upper Béji valley there is a marine conglomerate bed containing fragments of white and grey limestone, the latter being apparently derived from the massive cretaceous limestone. This unconformity is also indicated by the remarkable variations in the thickness of the white limestone, variations which are equally noticeable outside the limits of the area under description. As has already been remarked, it has a thickness of about 250 feet in the Sémbar pass, but on north side of the Mazár Drik anticlinal this is reduced to only 20 to 30 feet. So, too, on the road from Harnai to Loralai there is no distinct band of white limestone seen in the first anticlinal crossed by the Miráb Tangi, between Harnai and Tarwe Khan, but, at Dilkúna, only 5 miles further on, the white limestone is well developed, though the thickness was not estimated.

Another fact, pointing to an unconformity between the belemnite beds and those overlying them, is the occurrence of pebbles of white nummuliferous limestone, evidently derived from the uppermost white limestone of the belemnite beds, in a conglomerate which occurs near the top of the Gházij group both near Shahrig and to the south-east of Quetta.

Unaccompanied by disturbance.

But, although this unconformity is distinct and unmistakeable, there is not, so far as I have yet seen, any recognizable divergence from a perfect parallelism of dip between the beds above and below it. It was not, consequently, preceded by any marked disturbance of the beds already formed, and need not represent very great lapse of time. On the other hand, if the identification of the pebbles of grey limestone in the lower beds of the next succeeding system with the massive cretaceous grey limestone, is correct, there must have been a very extensive denudation, meaning a

considerable lapse of time, and the absence of any of the *Belemnites*, so abundant immediately below the unconformity, in the overlying beds points to the same conclusion. For the present, however, and until the results of more extended survey are available, it is impossible to determine the exact stratigraphical value of this unconformity.

Dunghan group.

The group which is met with immediately above this unconformity is, in many ways, the most interesting of all those met with; it is the same that was described by me as the Dunghan group. In the northern part of the area surveyed during the past season it presents the same character as it has in the Harnai district, that is to say, it is essentially a limestone group of great thickness. To the south a remarkable change comes in by the development of argillaceous beds in the base of the group, which encroach more and more on the limestone till, in the south-east, only a few of the uppermost beds remain as limestone, the rest of the group being mainly argillaceous with some subsidiary beds of sandstone and impure limestone. The limit of the change between the two facies is tolerably well defined, coinciding approximately with the road from Spintangi to Thal Chotiáli; and its abruptness is noteworthy. Thus, in the Dunghan mountain, the group is composed of limestones, some 2,000 feet in thickness, but within 15 miles to the east, in the Mazár Drik anticlinal and to the south-east in Sonári, there is not more than two or three hundred feet of limestone at the top of a thick series of shales.

Change of facies.

It is natural to ask whether such a sudden change of facies does not indicate a distinction between the two; such at first was the interpretation I was inclined to put upon it, and in the field maps the distinction was preserved to the last. A gradually increasing intimacy with their mode of occurrence, and a careful review of the evidence, has, however, convinced me that they are identical, in spite of their lithological dissimilarity.

Dés valley.

A very good exposure of the argillaceous facies of this group is seen in the Dés valley near Khattan. In the lower portion of this tributary valley the Ghązij shales are seen, which continue till a sheer sloping face is met with, composed of the pseudo conglomerate or true limestone breccia,[1] associated with flaggy limestone as at Khattan, the total thickness being about 100 to 150 feet. This is underlaid by 600 to 700 feet of grey shales, below which comes a group of beds which forms a well marked and easily recognizable horizon in all the sections of this district. The uppermost bed is a limestone, composed almost entirely of oysters (*Exogyra ?*), but also containing a few other fossils. In the section it is very dark coloured and impregnated with petroleum, which oozes from the exposed surface. This is underlaid by sandy beds, one band of which is red throughout, and the others frequently stained red with iron. Below the sandstones, in the Dés valley, comes a great thickness, probably over 1,000 feet, of shales, many beds of which are so abundantly fossiliferous as to become impure limestones. At the head of the valley, where the dip flattens down horizontal, they form cliffs surrounding an amphitheatre, and are conformably underlaid by unfossiliferous grey, green, and purplish shales. The limit between the profusely fossiliferous beds and those in which no fossils can be found is abrupt, but perfectly conformable, and

[1] Rec., Geol. Surv., Ind. XXIII, pp. 94, 95.

though no fossils are as a rule to be found in the shales, yet, in the Mazár Drik anticlinal, I found, low down in this portion of the group, a band of *Nummulites*, apparently identical with some of the forms found higher up.

The band of sandstones, stained with iron, and overlying oyster bed, can be recognized in all the sections in the southern part of the area included in the map and is important in the identification of this shaly group with the Dunghan limestone, for, in the Mazár Drik anticlinal, the whole thickness of the beds above it consists of limestones, which there is no difficulty in recognizing as the same as the unmistakeable Dunghan limestone close by. But the identification of the shaly group with the Dunghan depends mainly on the similarity of stratigraphical position of the two and the constant presence of the pseudo conglomerate, or limestone breccia, at the top of the group marking division from the overlying Gházij shales.

This bed forms well-marked and easily recognizable horizon throughout the area surveyed; it is almost invariably visible, where the Dunghan group is shaly in composition with only a small thickness of limestone at the top, and is frequently visible in the northern part of the area, where the group is composed of limestone throughout. How far its local absence may be due to imperfect action of the causes which led to the concretionary structure being developed, and how far to imperfect exposures of the bed, it is not altogether possible to say, but it is noteworthy that, in the northern portion of the area under description, the concretionary structure is less well-developed, and here the observed occurrences are least frequent, while in the south and east, where there is hardly a contact section in which it cannot be detected, the concretionary structure is so well developed that it is frequently almost impossible to believe that it is not a true conglomerate. I have, however, no reason for departing from the conclusion come to last year regarding the nature of this structure, and, in spite of the very striking appearance presented by individual exposures, there are several features in its mode of occurrence which are incompatible with the supposition that it is a true conglomerate; these are, the absence of any important variations in thickness, its interstratification with fine grained flaggy limestones, the absence of any coarse grained deposits associated with it, and, above all, the absence of any rock, of older date, similar to that of which the "pebbles" are formed.

The presence of this peculiar and easily recognizable rock at a definite horizon has been a most important aid to the geological mapping of the country, as it enabled the boundary between the Dunghan and Gházij groups to be determined with accuracy, when this would, in its absence, have proved almost impossible of accomplishment.

Fossils.

Concurrently with the change of facies of the Dunghan group it becomes abundantly fossiliferous, and a large number of specimens were obtained from the shaly beds. When the fauna of this group comes to be examined in detail, I anticipate it will lead to results as striking in their way as the remarkable change which, within twenty miles, converts a group of marine limestones, 2,000 feet in thickness, into an almost entirely argillaceous group. Until the fossils collected have been examined by a competent palæontologist it would be presumptuous to hazard an opinion as to the palæontological affinity of the fauna as a whole, but it presents certain striking anomalies which cannot be passed over in silence.

Anomalous fauna.

Among the *Cephalopoda* collected were fragments of two species of *Ammonites*, *Crioceras*, and besides these I have been shown *Ceratites* and *Baculites*, which were found by Mr. R. A. Townsend in the Dés valley; among the echinodermata fully half the specimens found belong to the order *Echinoconidæ*, and an oyster very like *O. carinata* is not uncommon. These would ordinarily be held sufficient to stamp the fauna as cretaceous, or at any rate upper secondary, yet this fauna not only occurs above the white limestone of the belemnite beds, in which *Nummulina* occur, but is accompanied in the same group by an abundance of specimens of *Nummulina* belonging to three or four species. I am aware that the genus *Nummulina* has been found in beds of carboniferous and of secondary age, but it is uncommon and, as yet, it has always been accepted that any beds in which the genus is abundantly represented are of tertiary age.

Under these circumstances it must remain an open question whether we are to regard the Dunghan group as oldest tertiary, or newest secondary, in age. Dr. Blanford in his memoir [1] regarded the Dunghan limestone, near Harnai, as lower nummulitic, and very naturally so, for the almost only recognizable fossils it contains are foraminifera, mostly *Nummulina*, but in the Suleiman hills he took the "limestone breccia" to mark the base of the tertiary system. As may be seen from what I said above, there is a contradiction here and, as matters stand, it is impossible to say which of the two views is correct. If the top of the Dunghan group represents the lower limit of the tertiaries, we have to acknowledge an extreme abundance of the genus *Nummulina* in beds of cretaceous age; if the bottom, then the *Ammonoidea* are represented, in beds of tertiary age, by several genera and species. A third interpretation is open, and probably it will prove the true one, that the Dunghan group represents the gap between the Secondary and Tertiary period in Europe.

Distribution.

The distribution of the Dunghan group is a large one, and is best explained by a reference to the map. In the north-western portion of the area, where it consists mainly of limestone, it forms high hills and mountains; to the south-east, where it is shaly, this is much less noticeable as, in most cases, the thin shell of limestone has been broken through by denudation, and the easily removed shales exposed.

Gházij group.

The Dunghan group is conformably overlaid by the Gházij group which presents the same character as was described in my previous paper and will not require lengthy notice here. To the north of the Thal Chotiáli plain some coal seams occur in this group, and near Khattan a thin band of impure coal is found near the top of it, but throughout the rest of the large area it occupies no coal was seen. Fossils are not very abundant except near the top of the group.

Spintangi group.

The Gházij group is overlaid by the Spintangi beds, not only with most perfect conformity, but with an absolute obliteration of any definite boundary. In the neighbourhood of Khattan several thin beds of white limestone, of the Spintangi type, occur among the Gházij shales, and green shales are found interbedded with beds which appear to be the equivalents of the Spintangi group at Spintangi. It has become evident that the lithological discrimination of the two groups is impossible, and, on palæontological grounds, it will

[1] Memo., Geol. Surv., Ind., XX.

be equally difficult, for the fauna of the shaly beds is not extensive, and naturally is very different from that of the clear limestones, and the same fossils, at least so far as the more abundant forms are concerned, appear to be common to the limestone bands in the Gházij groups and to the main body of the overlying Spintangi group. Under these circumstances, seeing what a large share the mere change of condition would have in bringing about the change of fauna, a line of demarcation drawn on palæontological grounds would no more represent a definite epoch than one drawn on purely lithological grounds. In fact there is no real distinction between the groups, and there is good reason for supposing that, to the south-east of the limits of the map, beds would be mapped as Spintangi which were of contemporaneous origin with some that have so far been mapped as Gházij.

Want of definite boundary.

Although the boundary between these two groups has none of that definiteness which attaches to the other boundaries, it has been inserted as a matter of convenience, for not only does the sub-division of the nummulitic beds above the Dunghan serve to render the structure of the country recognizable at a glance, but it serves to show to the distribution of two strongly contrasting types of deposit.

A noteworthy feature of the Spintangi beds in the southern portion of the area mapped is the thickness of the gypsum beds it contains. Along the upper part of the Khattan valley they are very conspicuous on the scarps, and near Mámand there is, according to Sub-Assistant Hira Lál, a bed of 50 feet thick, besides four others aggregating 33 feet in a total thickness of about 400 feet near the middle of the visible section of the group.

Siwalik.

The Spingtangi group is overlaid to the south by Siwalik beds of the ordinary type, and these are the only indubitable Siwaliks in the area examined. There are, however, some other beds whose true classification it is difficult to determine; from their aspect they might well pass for Siwaliks, but as it is very doubtful if they are contemporaneous or were ever continuous with any of those beds which have been mapped as Siwalik along the margin of the hills, I prefer to class them separately for the present.

Sub-recent gravels of Mámand.

The most important of these is an area of disturbed sands and gravels lying east of Mámand. They consist mainly of old river shingles, but, where they have been cut into, these are found to be interbedded with soft sandstone, little harder than rock-sand, and clayey beds; they have mostly a distinct dip which in one place rises to 50°. Besides this main exposure there are three outliers, perched on the top of hills, at the eastern end of the Mámand plain. These gravels are evidently old deposits of the same stream which now flows to the south of Mámand; but, since they were formed, there has been some disturbance of the beds and an alteration of the course of the drainage, partly due to this disturbance, and partly to a lowering of levels along the band of easily denuded Gházij shales, a little way to the south.

Further down this stream, near Kardari, there is a large development of gravel deposits which rarely show any noticeable disturbance, but have been deeply cut into by the streams.

Béji valley.

In the Béji valley there is a large expanse of gravel deposits in which no signs of disturbance were seen. They have, however, been cut into, to a depth of nearly 100 feet in places, and, just above the

junction of the Bareli, there is a hill of Gházij shale, capped by sub-recent river gravels.

Thal Chotiáli.

In the Thal Chotiáli plain, separating the main area from the Karáhi plain, there are some low hills of gravels, which have been bent up into an anticlinal. These are evidently old deposits of the river, before its gradient was checked, and have since been disturbed. They will be again referred to when treating of the Thal Chotiáli plain.

Disturbance of gravels at Panun.

The most remarkable instance of disturbance of these sub-recent river gravels is exhibited by those of the Panun valley (Pano of the map). Between the Sherki hill and the western end of the Mazár Drik anticlinal there is a great thickness of gravels, through which the stream has cut its way. At their northern limit these are in direct contact with Gházij shales, and have been bent up vertical and in places as much as 30° beyond the vertical, so as to acquire an apparent dip to N. at 60° (Plate III). The dip is very local; within 300 yards to the south it has almost disappeared, and, throughout the area occupied by these gravels, no signs of disturbance were seen, except in the immediate vicinity of its northern margin.

Recent gravels and alluvium.

Gravels of recent date are abundant in all the stream valleys. They have not been considered of sufficient importance to be mapped in detail. Besides the numerous smaller deposits in the stream valleys there is a large area in the Quat Mandai valley, covered principally by gravels, but in part also by fine-grained alluvial deposits.

Landslips.

Among recent deposits must be classed landslips, which are more common than would be expected in so dry a climate. There is a very large and conspicuous landslip at Kuriák Tangi, 8 miles east of Spintangi, which extends for nearly 3 miles across the valley, having come from the hills to the south. This landslip must have blocked the drainage for a time, as the Tangi is cut through its substance, between its source of origin and termination.

Smaller landslips are common where the Gházij shales are exposed on a hillside, being induced by the manner in which these shales weather into slimy mud which will move over very small gradients. A very striking instance occurs south of Sonári, where, on the watershed between the drainage of the Chákar and Béji valleys, the whole outcrop of the Gházij shales is completely concealed by a thick layer of huge angular masses of Dunghan limestone. It is, at first sight, almost impossible to suppose that the limestone is not *in situ* here, but, on either side of the ridge, these blocks are seen to overlie the edges of nearly vertical beds of the Dunghan and Spintangi groups.

Alluvial and loess plains.

The most interesting and important of the recent deposits are, however, the numerous valley plains of fine-grained loess or alluvium. These vary in size from the numerous small "Thals" on the hillsides, too small to be distinguished on the map, to the great plain of Thal Chotiali, and the still greater plain of the Sibi "Pat."

The Thals are small hollows, perched about the hillsides and on the hill tops, some due to solution of the underlying limestone, others to small landslips, in which accumulations of dust and rain wash, from the surrounding hillsides, form a very gently sloping floor. They are mostly cultivated by the Maris, who have not yet been

able to get over the objection, born in old predatory days, to cultivating the valleys, where the crops are visible to every passer-by, and would probably have been reaped by some other person than the man who sowed them.'

The larger plains, those of Mámand, Samach, and Púr, as well as some of the smaller ones, evidently owe their origin to differential movements, or warping, of the surface, by which the drainage was checked, and the accumulation of fine grained deposits rendered possible.

Mámand.

The plains of Púr and Mámand are both situated in synclinal hollows of the underlying rock; in the latter case the old escape of the drainage can be traced on the south side of the plain, and the old river gravels, deposited in former times when the streams flowed across the area now covered by the plains, extend over a low divide and slope gently northwards under the loess. The deposit which fills the hollow that was formed is fine and uniform in grain, of a pale grey colour, and very calcareous; the very few and shallow sections exposed show no signs of stratification, and there seems no reason to doubt that it is, in the main, wind blown loess, derived from the dust blown off the surrounding hills, supplemented to some extent, near the margins of the plains, by matter brought in by the streams. The history of the plain is evidently as follows: At first there were river valleys of the ordinary sort draining to the south. After these had been well excavated, the compression to which these hills have been subjected caused the stream bed south of the Mámand plain to rise at a greater rate than the stream could cut down its channel. The first result of this was to form a deposit of gravel filling up the hollow, but the rise of the barrier went on at a greater rate than the deposit, and a hollow was formed which the materials brought down by the stream could not fill and from which the dust that accumulated could not be washed away; so the loess gradually formed and by degrees spread over the gravels, hiding them and obliterating all minor inequalities of the ground to form a nearly level plain, now cultivated over almost the whole of its area. The whole of this process, from the original carving out of the valleys to the formation and filling up of the basin, every stage of which must have been very slow and gradual in its progress, has taken place since the deposition of the sub-recent gravels mentioned above, and, when it is remembered that these are among the latest members of the tertiary period, if indeed they are tertiary at all, it gives a most striking indication of the incomprehensibly vast periods of time which the geological record must necessarily cover.

Samach.

The Samach plain differs from that of Mámand in being formed on the crest of an anticlinal, but its origin is none the less evidently due to differential movements of the surface. Its history has been as follows: In the first instance an anticlinal hill of Dunghan limestone was formed, whose crest was broken through by denudation, exposing the easily denuded shales of the lower part of that group and the Belemnite beds, and a tolerably deep valley was consequently formed, but the drainage of this valley had to cross the axis of the anticlinal, and, in consequence of further compression, the ground along the axis rose and checked the drainage, after which the subsequent history was much the same as that of the Mámand plain.

The fine grained deposits of Samach differ somewhat from those of Mámand in appearance. Whether they are calcareous or not I forgot to note, but their colour is

a reddish brown, and they are much more loamy in appearance and texture. The difference is doubtless due to the amount of fine grained argillaceous matter washed down into this plain, whereas at Mámand the bulk of the debris brought down by the streams was limestone gravel, which came to rest close to the edge of the hills.

In the Sarpach plain we can see the beginning of the end, for the barrier has been partly cut through and the stream has cut back into the plain, converting its eastern end into a maze of perpendicular-sided ridges and channels, while the rest of the plain still preserves its original smooth surface.

The other plains of loess present very much the same character and history as these and do not require further notiee here, but the great Thal Chotiáli plain, 45 miles in length and 12 in breadth, presents so many features of interest that it cannot be passed over without some mention.

Thal Chotiáli.

The western half of the plain is a barren treeless expanse of pale grey loess, at first sight level throughout, but having in fact slight gradients to the west and south, where water collects after heavy rain. In the eastern end the soil is of a reddish colour and is less of a dead level, some slight rises being perceptible, especially near Gumbaz; and along the banks of the stream, which flows past Gumbaz and Chotiáli, there is a park-like strip in which tamarisk and poplar trees shade the stream and are dotted about with green sward under their shade, forming a view not unpicturesque in itself, and positively beautiful by contrast with the barrenness of the surrounding country. The Karáhi plain, too, is in spring a mass of verdure. In March last its centre was occupied by an expanse of water in which numberless waterfowl and waders were disporting themselves, and on the stretch of ground surrounding it countless herds of sheep, cattle, goats, and donkeys were grazing.

The fine grained deposits of the plain are of two distinct types. One of these is pale grey in colour, highly calcareous and very obscurely stratified. It corresponds to the loess deposits of the Quetta plain. The other is of a reddish brown colour, imperfectly but distinctly stratified, which appears to correspond to the undisturbed equivalents of those beds which, in the Quetta district, have been classed as Siwalik.

The drainage of the plain presents features of interest. On the north two considerable streams enter the valley. One of these drains the Sinjáwi valley and flows past Dúki. The ordinary flow of this stream is entirely absorbed by cultivation and the flood waters spread out over the plain, partly soaking into it, partly accumulating in the hollows, whence they gradually disappear by percolation and evaporation.

The other is the Hanambár stream, which is joined near Chotiáli by the Naréchi flowing from the east, and the combined waters flow out through the hills at Tang, or, as it is more commonly called, the Gháti bridge, being there, and for the rest of their course to Babar Kach, known as the Béji river.

This, the only outlet for the drainage of the Thal Chotiáli plain, is not the original course of the drainage, and is, moreover, of very recent date. The hills on either side of it are low, and slope gently to the stream,[1] which does not flow in any deep cut gorge or steep-sided valley marking the long action of denudation. There are no traces of river gravels, and in the plain above the hills the stream flows in a narrow

Present drainage outlet.

[1] See Plate IV.

channel of 20 to 30 feet deep, from which two nullahs are cutting back on either side into the loess deposits along the foot of the hills. Everything marks the outlet as geologically of very recent origin. The stream bed, after entering the hills, is formed by deep, stagnant reaches, separated by small waterfalls or rapids, where the water flows over a steep slope of angular debris. The deepening of this channel must proceed slowly, for it can only take place through the power of the floods to tear angular masses of rock out of its bed, the waters having been deprived of all solid matter, too coarse to be carried in suspension, long before they cross the plain. This absence of pebbles borne along by the water has deprived the stream of much of its abrading power and the outlines of the stream bed, and of the loose fragments in it, are everywhere almost angular. Occasionally, however, they exhibit indistinctly the same sort of sculpturing as is seen on rocks exposed to the action of wind blown sand,[1] which is in this case caused by the fragments of sand carried along in suspension by the water.

Old course of the Béji.

After a course of a couple of miles, down what has all the appearance of the valley of a small tributary stream, as in fact it originally was, there is a broad open valley leading up to the west, and immediately beds of river shingle appear. Following up this side valley it can easily be recognized as the old outlet of the river, which once gathered all the drainage of Thal Chotiáli. It is broad and open, and the Gházij shales, which are the rock *in situ*, are very little seen, owing to a cover of river gravels cut into by numerous small stream beds. The surface of this gravel deposit gradually rises to the west and ultimately forms a broad and almost imperceptible ridge at the eastern end of the Karáhi plain. The same gravels are seen in the ridge of low hills, which runs east and west, north of the Karáhi plain, where they are disturbed, forming in places the whole of the ridge, but, in others, only a skin over a central core of older rocks.

We have here the old course in which the Béji river flowed; its flow was checked by a rise of its bed along the anticlinal which runs south of the Karáhi plain, and finally closed by the rise of the ground at its eastern end. The formation of the low hills, separating this from the main area of the Thal Chotiáli plain, was of later date, and it is noteworthy that these hills lie along the continuation of a distinct anticlinal.

History of the plain.

The evidence that the compression and folding of the strata did not take place at one definite period and then cease, but that it has been a gradual process, going on concomitantly with the erosion of the river valleys, is peculiarly abundant in the Thal Chotiáli district, and it would be most interesting to work out the details with greater thoroughness than I was able to do on my somewhat hurried visit. We have first a certain amount of disturbance, the formation of a large drainage basin and extensive denudation. Then we have earth movements by which an area of closed drainage was formed and deposits accumulated; at a subsequent date a further movement caused the elevation of the low hills between Ismail Khan and the Karáhi plain, and, at a still later date, some of the fine grained loess deposits along the margin of the hills west of the Gháti bridge have been locally elevated and deeply cut into by the resulting erosion. Meanwhile the surface of the plain had gradually risen,

[1] See Records, Vol XXI, page 159.

Lithographed & Printed at Geological Survey Office

PLATE. I REVERSED FAULTING IN GHAZIJ BEDS NEAR THE DUNGHAN MOUNTAIN

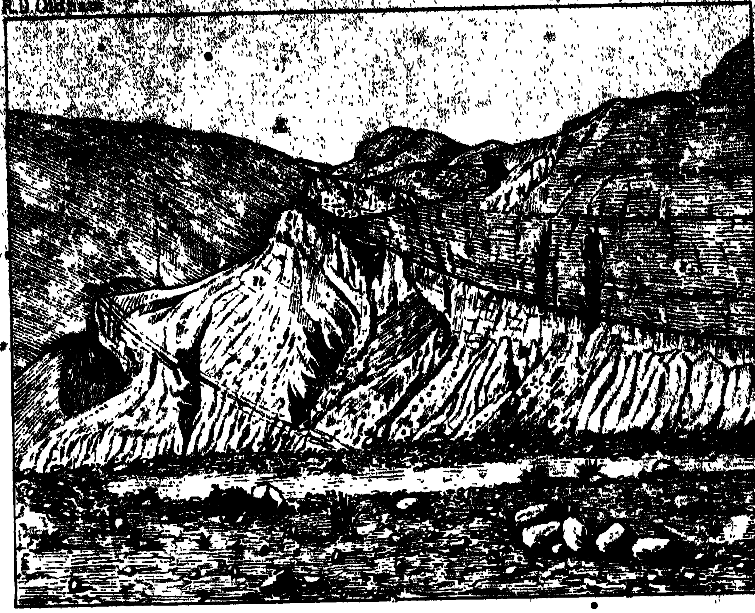


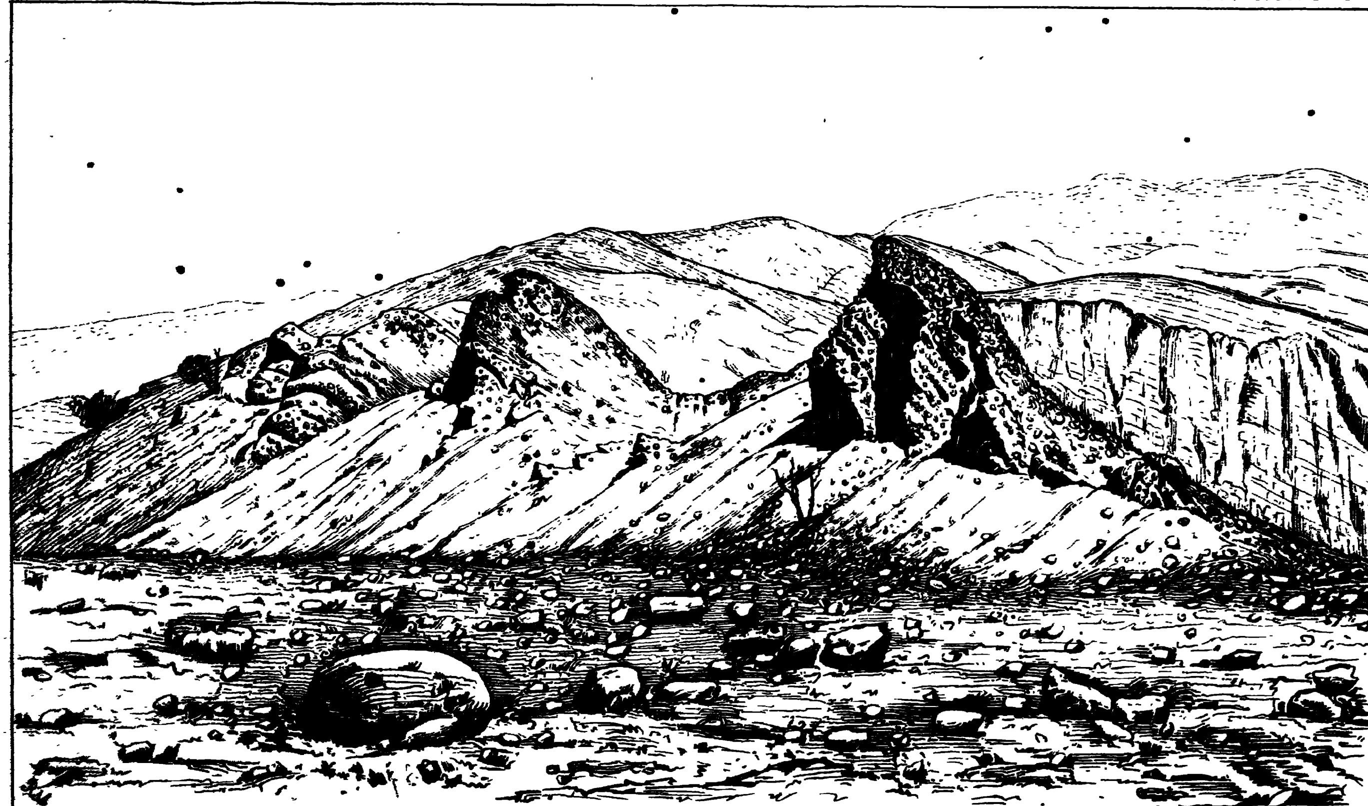
Fig. I

Lithographed & Printed at [illegible]

PLATE. II. JUNCTION OF NUMMULITICS & SIWALIKS ON ROAD TO [illegible]
SHOWING [illegible] THRUST PLANE.
[illegible]

R. D. Oldham.

Records, Vol. XXV Pt. I



Lithographed & Printed at Geological Survey Office.

PLATE. III. DISTURBED RECENT RIVER GRAVELS AT PANUN

Lithographed & Printed at Geological Survey Office

PLATE. IV. OUTLET OF BÉJI RIVER FROM THE THAL CHOTIALI PLAIN.

extending up a small tributary valley which originally flowed northwards past where the Gháti bridge now stands, till its level reached that of the divide. Some of the flood waters then flowed over this and, washing away the weathered and easily removable rock at the surface, established a defined channel, along which much of the drainage now escapes. Such are the main points in the history of the Thal Chotiáli plain.

Economic geology.

The economic results of the last season's work have been as disappointing as its purely geological results have been interesting.

Petroleum.

Traces of petroleum are widespread, and were found in the limestones of the Dunghan group at several spots throughout the area surveyed. It is most concentrated along the Khattan anticlinal. Old flows can be found in the Dés valley, and, in a corresponding valley, which drains the south side of the anticlinal. The shows are most abundant about the horizon of the red sandstone mentioned in the description of the Dunghan group. It is worthy of note that where this group is most profusely fossiliferous, most conspicuous signs of petroleum are found, and it is impossible not to hazard a guess that the coincidence is not accidental. As this petroleum has already been noticed in a previous paper[1] and been made the subject of a special report, I shall not enter further into the matter.

Coal.

Coal was found near Duki in several places, but the thickest seam seen only measured 14 inches, so it is not likely ever to be of importance. The distance from any centre of demand would very much detract from its value even if good seams existed.

Gypsum.

Gypsum was observed in great abundance and thick beds, one measuring 50 feet, near Mámand and in the Khattan valley; it will be long before it is worked for profit, though it is of excellent quality, and, if it could be easily got out, could be used for ornamental purposes.

Petrological Notes *on the* Boulder-bed *of the* Salt Range, Panjáb, *by* C. S. MIDDLEMISS, B.A., *Geological Survey of India.*

INTRODUCTION.

The rock-formation known as the Boulder-bed of the Salt Range is one that has attracted much attention of late, as previous papers in the Records by Warth, Oldham, Blanford, Waagen, Medlicott, and myself during the last few years can testify. It is unnecessary here to do more than shortly re-state what has now been definitely established as regards its age and mode of formation. Instead of there being several crystalline boulder-beds at different horizons in the range, it has been abundantly proved that there is but one bed forming a bottom layer to the Speckled Sandstone stage and its eastern representative, and resting unconformably on the older palæo-

[1] Rec., Geol. Surv. Ind., XXIII, page 104 (1890).

zoic rocks beneath. From the great frequency of polished, striated and facetted boulders set in a clay or shaley matrix, and from the identity of these characters with such as are well known in pebbles of the boulder clay of *the* glacial epoch, it has now been generally accepted that the Salt Range Boulder-bed is a witness that glacial conditions prevailed over this part of the earth in palæozoic times. Furthermore, it is conjectured with reasonable probability that the (in many ways similar) bed in Peninsular India known as the Talchir is of the same age.

These facts and opinions being admitted, it occurred to me that a microscopical examination of the crystalline boulders, and a comparison of them with slices of rocks from the Maláni neighbourhood—the conjectured source of the boulders—might bring out some positive points of identity between the former and their supposed parent rock, whence they had been carried by the agency of ice. Although no specific identities have been established, I give the following account of the examination of a small set of typical samples of pebbles from the boulder-bed, in the hope that, ultimately, their actual source may be tracked down[1].

No. (1), $\frac{8}{467}$, 650. (*N.B.*—The first number in brackets is my own running number, the second is the registered number of the rock specimen, and the third the number of the microscope slide). In the hand specimen this boulder appears to be a coarse gneiss or gneissose-granite, roughly banded, and containing pinkish felspar, clear quartz, and muscovite. In a fairly large slice prepared for the microscope the gneissose structure is not noticeable. To whatever cause the banding of the rock be due, it may be remarked that it is of a different type from that usually found in the gneissose-granite of the Lower Himalaya. There is neither augen, lenticular-tabular, nor tabular structure, as in the latter.

The minerals present, in order of importance, are quartz, plagioclase, muscovite, biotite, magnetite, and apatite. In another section of the same rock Mr. Holland has recognised much pinite.

The quartz is present (1) in large grains composed of aggregates of distinct optical units. Magnetite and apatite are included in the quartz grains in small quantity. The usual minute inclusions forming dusty-looking lines traverse each grain, and there is also seen a fine parallel striation indicating zones of growth. With crossed nicols these dusty-looking lines of inclusions and the parallel striation are seen to pass without deflection through several of the optical units into which the grain then splits up. The individual units of this polysynthetic group are generally irregular in shape, but at the same time showing an approximation to a hexagonal outline. The distinctness of the units from an optical point of view and their material continuity, are shown in a rather thick section by the rainbow halo round each where it overlaps or is overlapped by its neighbour. (2) Quartz is also present along certain lines in the slice forming a finely granular mosaic with plagioclase and muscovite. These lines probably coincide with the macroscopical banding of the rock, and are due to crushing of the mass.

The polarization colours and extinctions of the optical units of the quartz aggregates are generally uniform in each unit; but locally a unit shows a watered colour

[1] My thanks are due to Messrs. P. Lake and T. H. Holland, of the Geological Survey, for superintending the cutting of the slices and for efforts to match them with rocks from Peninsular India.

(brilliant purple and azure blue, or pale lemon and deep ochre) with a slightly undulose extinction.

The felspar (1), like the quartz, occurs in large irregular grains, with a defined but irregular border next the large quartz grains, but with a ragged and intermingling border next the finely granular mosaic of quartz, felspar and mica. It is somewhat opaque, and generally includes many fine needles of apatite. It sometimes presents a sharp and fine twinning on the albite plan, and at other times broad and often irregular lamellæ which merge into each other insensibly. The ends of the twin lamellæ at the border of a felspar grain are often bent, sometimes spread out like the fingers of a hand, and sometimes completely ruptured. One felspar is ruptured along two lines crossing at right angles the twinned lamellæ, so that on each side of the lines of rupture they do not join properly. In this section of felspar also undulose extinction is prevalent. (2) The felspar is also present as a constituent of the granular mosaic.

The muscovite (1) is present in irregular packets of the usual kind in granites, but with slightly bent folia; (2) in the granular mosaic; and (3) as a cryptocrystalline aggregate in patches among the mosaic.

The biotite is only found in a small nest with cryptocrystalline structure.

The magnetite in minute proportions is dotted through the slice.

The apatite in minute characteristic highly refracting prisms and hexagonal sections is chiefly confined to the felspar.

This specimen resembles in a general sort of way No. $\frac{70}{60}$, 769 from Daolatgar Ajmir, but not sufficiently to make it probable that the boulder came from that locality.

No. (2) $\frac{8}{468}$, 651. In the hand this rock also is seen to be a coarse gneiss or gneissose-granite, but not so coarse as the last specimen. It possesses deep flesh-coloured felspar, much biotite, and the quartz is of a dark bluish grey tint. The banded appearance is fairly well seen.

In thin slice under the microscope the individual minerals are better seen and are as follows:—Quartz, felspar, biotite, magnetite, and sphene (?)

The quartz in this slide is in two or three irregular grains, but not so distinctly separated the one from the other as in the last section. As before, however, it is made up of a large number of optically distinct individuals, whose shapes, though sometimes inclined to be hexagonal, are more generally elongated in one direction into lens-shaped bodies, separated round their margins from each other by a very fine-grained mosaic of apparently powdered quartz. It is evident that differential movements of the particles of the original grains or layers of quartz have taken place along waving lines so that it has been sheared after the manner of the felspars and quartz in the microgranulitic rocks of Khairna described by me (Rec., G. S. of I., XXIII, pt. 1). In addition, every one of the optical units, when they are in the least lens-shaped or irregularly drawn out, show blurred colours with crossed nicols, and completely undulose extinctions. The general appearance then is not unlike that of 'marbled' paper. So far these lenticular and irregular optical units, with the very fine mosaic between them, are only well seen with crossed nicols, and the lines of minute inclusions pass uninterruptedly from one to the other. But there are still other parallel fissures and cracks filled in with secondary quartz or with powdered residuum from the original walls, and these can be seen quite plainly without the aid of polar-

ized light. Magnetite is enclosed in the quartz in small crystals and dusty grains, and so also are a few crystals of sphene (?). The extremely minute inclusions in the quartz throng the substance in swarms. They, together with the magnetic dust, may presumably be the cause of the blue colour of the quartz, so noticeable in the hand specimen.

The felspar is in very irregular grains and throughout the slide is generally altered into a finely granular aggregate, among which patches of small size in the body of the felspar, and of larger size at the margins, remain unaltered. The unaltered parts show a very fine lamellar structure as if the result of twinning. Sometimes it displays the 'plaided' appearance of microcline. Lines of differential movement, which have been remarked in connection with the quartz, are also observable in the bending and waving of the felspar lamellæ. Undulose extinction is also prevalent.

The biotite is in irregular layers, and markedly illustrates the mechanical deformation of the rock.

Magnetite is sparsely disseminated through the slice in small grains and crystals.

No. (3), $\frac{8}{469}$, 652. Macroscopically it is a coarsely granitic or gneissose rock, mottled red and black. Only a faintly linear arrangement of the minerals is visible.

Under the microscope the slide appears as a finely granular intergrowth of quartz and felspar grains, sometimes becoming regularly micropegmatitic, among which larger idiomorphic crystals of felspar, sometimes with well-preserved outlines, are thickly strewn.

The felspar is by far the most largely represented in this slice, and it has some very complicated characteristics. (1) It occurs in rather large crystals, the crystallographic outlines of many of which are fairly distinct. The central portions of these are much darker than the outer zones. Other less distinct indications of growth zones can also be seen. Several of these felspars appear to be untwinned. They extinguish light at once and completely, without any banded polysynthetic twinning coming into view. Others show a very faint striation, which becomes just visible when the point of maximum extinction of the section as a whole has been reached in revolving the stage of the microscope. Others again show a very fine sharp lamellar twinning, and others the ordinary aspect of microcline. (2) Felspar also occurs in small micro-crystals irregularly scattered as inclusions in the former. (3) It also occurs in a sort of micro-granulitic ground-mass between the larger constituents of the rock. (4) It is associated with quartz in an ill-defined micropegmatite.

The quartz is present (1) in large grains often marginally passing into (2) micropegmatite; also (3) in smaller grains as inclusions in the larger minerals; and (4) in the micro-granulitic ground-mass.

A badly preserved green mineral in small quantities in nests is present.

Magnetite and apatite are also represented.

The whole rock is very much confused, but it does not suggest any form of mechanical deformation. I should be much puzzled to specifically classify it.

No. (4), $\frac{8}{470}$, 653. In the hand this appears as a fine-grained granitic rock of reddish brown colour.

Under the microscope the slide reveals a medium-grained granitic rock, composed of larger grains of quartz dotted about irregularly in a slightly finer groundmass which is composed of smaller grains of quartz and microcline, with a little plagioclase and a green mineral, hornblende (?)

The microcline is in places intergrown with the quartz but in an irregular way, the structure merging into an ophitic structure, wherein plates of microcline include small quartz grains.

Small portions of a green mineral, probably hornblende, are seen, much disfigured by alteration and deposition of oxide of iron, which has spread about in between the other constituents of the rock in the neighbourhood.

In many parts of the slide original magnetite, is disseminated in small well-formed crystals.

The whole rock has a very pellucid and defined appearance, and, with the exception of the green mineral, has suffered but little alteration, nor are there any evidences of dynamic metamorphism.

No. (5), $\frac{8}{471}$, 654. The hand specimen is a dark purplish-grey, compact rock, with large, somewhat eye-shaped porphyritic crystals of flesh-coloured felspar. It contains inclusions of a dark compact probably hornblendic rock.

Microscopically it appears as a typical micro-granulitic rock, containing porphyritically developed (1) large rounded grains of quartz of uniform crystalline structure; (2) felspars altered in many places, but possessing finely-twinned lamellæ such as characterize plagioclase and also broader twins of another kind superposed. One section of felspar exhibits a simple binary twin.

There are a few patches of ill-defined greenish mineral, which has apparently suffered much alteration.

The micro-granulitic ground-mass is in many parts minutely micropegmatitic. The quartz of the ground-mass can be picked out in ordinary light from the felspar, which is slightly yellowish grey in colour. In this light the micropegmatite can be seen very distinctly, and it appears to constitute a considerable portion of the ground-mass. It seems at first sight that the intergrowth of the quartz and felspar has taken place at innumerable centres in the ground-mass, separately, and not uniformly, over large spaces.

Magnetite is present in small quantity in minute crystals and crystalline aggregates.

No (6), $\frac{8}{472}$, 655. This rock is of common occurrence and may be said to characterize the Boulder-bed. It appears in the hand as a fine-grained, flesh-red granophyre, with blebs of blue quartz and hornblende in small quantities.

Under the microscope it appears as a beautiful micropegmatite, with quartz and felspar porphyritically developed.

The micropegmatitic structure is very distinct and extremely beautiful. By ordinary light the pellucid quartz is visible in uniform, or triangular individuals with truncated apices, and ranged in lines or in more or less vermicular and parallel streaks converging towards centres, lines or round porphyritic quartz and felspar crystals. There is thus a faint tendency to what is known as centric structure. The clear quartz individuals, thus arranged, appear inlaid in a pale yellowish-grey matrix, the latter being altered felspar, which still retains considerable power of lightening and darkening uniformly between crossed nicols. The whole of this micropegmatitic ground-mass, when the nicols are crossed, splits up into differently oriented optical groups of units, without any particular shape that I could discover, except that the groups are bounded by more or less straight lines. Each optically uniform quartz group is approximately coincident with each intergrown optically uniform felspar group, though they do not extinguish light simultaneously.

The generally accepted theory of eutectic compounds crystallizing often in a pegmatoid manner, that is to say, by mutual simultaneous intergrowth, is one which has a great deal of evidence in its favour. There is one point, however, that I would notice in connection with the question, namely, the apparent difficulty of always distinguishing the so-called quartz of corrosion structure from a product of mutual intergrowth of quartz and felspar. There seems to me to be a more than superficial relation between the two. I have referred to this point before (Rec., G. S. of I., XXI, pt. 1), and it has again been brought to my mind by the recent paper by M. Al. Lacroix on the scapolite-bearing rocks of Ceylon and Salem translated by Mr. Mallet (Rec., G. S. of I., Vol. XXIV, pt. 3). It seems to me that quartz of corrosion in felspar, and quartz intergrown with felspar, may sometimes resemble one another so nearly that it is difficult to believe that they had an entirely different origin in each case, namely, by subsequent corrosion of the felspar with deposition of secondary quartz in the one case, and by mutual inter-growth and crystallization of the two minerals in the other case.

Among the micropegmatitic ground-mass there are grains of quartz of compound crystalline structure but much cut up by fissures. These fissures are sometimes widely open and show either invasions of some green mineral or of the altered felspar material. Crystals of felspar very much altered like that of the micropegmatite, but with regular outlines, are seen scattered through the ground-mass : and occasionally round them and round the quartz there is a partial coincident extinction of the micropegmatite. The felspar shows no compound twinning indicative of plagioclase ; there is one binary twin in the slide.

There is a little green mineral in the rock which is probably altered hornblende, and magnetite is very scarce.

No. (7), $\frac{8}{473}$, 656. Macroscopically a black rock, with compact pitch-stone-like matrix, containing small white and pink patches of quartz and felspar.

Microscopically the slide appears as a quartz-felsite or quartz-rhyolite. The ground-mass is yellowish or brownish-grey in ordinary light with flow-structure extremely prominent. The ground-mass is not of uniform colour or structure. Portions are more or less glassy, and remain dark between crossed nicols ; other portions are finely felsitic, and others again finely spherulitic, giving an assemblage of black crosses with crossed nicols. It seems probable that the different nature of these patches indicates that the whole did not solidify at once, but that half-solidified portions of a flow were broken up and then half fused over again.

Quartz is present in clear, single, idiomorphic crystals, occasionally corroded at the edges. Felspar is scarce, but not entirely wanting. Magnetite is relatively abundant, as small crystals, or groups of crystals, and also in streaks and shreds following the direction of the flow-lines.

There are lacunæ and small patches of viridite.

No. (9), $\frac{8}{478}$, 658. In the hand a fine-grained trappoid rock of black colour.

Under the microscope this appears as a clastic rock, an ordinary grit of very fine grain. There is a pale yellowish green mineral giving aggregate polarization colours between crossed nicols, probably decomposed mica: Magnetite in grains is also present.

No. (9*a*), $\frac{8}{478}$, 659. This is also a fine-grained clastic rock, finer than the last.

No. (10), $\frac{8}{477}$, 660. In the hand this is a banded mica-schist containing black mica and quartz.

The microscope slide displays a typical crystalline mica-schist, with dark mica and a fair amount of orthoclase and plagioclase besides the quartz. The dark mica is of olive green tint, though there is a little white mica as an accessory. The packets of biotite arrange themselves in among the quartz grains and are sometimes bent. In ordinary light the ground-mass of quartz is quite transparent and structureless, save for a few small inclusions, probably minute garnets. With crossed nicols it breaks up into an irregular aggregation of different optical units, most of which are irregularly lens-shaped, with the long axes parallel to the foliation. Undulose extinction is frequently observable in the quartz. That the rock has succumbed to pressure at right angles to the foliation I have no doubt, but it seems to me a probable surmise in this case that the rock was formed originally as a mica-schist under enormous pressure.

No. (11), $\frac{8}{478}$, 661. Macroscopically a dark grey quartzite.

Under the microscope it appears as a typical quartzite.

The most noticeable feature in this slide is the abundance of large inclusions in the quartz grains.

No. (12), $\frac{8}{479}$, 662. A dark purple quartzite (?).

Microscopically it contains much felspathic material and might represent a metamorphosed arkose.

No. (13), $\frac{8}{480}$, 663. Macroscopically it is a purplish grey, fine-grained volcanic ash (?).

Under the microscope it contains apparently a fine-grained felsitic ground-mass, with an indefinite parallel-banded structure. But it has some curious features. The whole of the ground-mass does not split up into a mosaic, but there appears to be underneath it all a completely isotropic base in which crystalline particles show up here and there.

There are grains of quartz scattered about in the matrix, but they are all much split and broken. None of them possess those corroded outlines so common among the quartz-grains of quartz-felsites. There are some crystals of felspar with binary twins, also much fractured.

Much opacite occurs in smudgy streaks.

The nature of the ground-mass, and more especially the slight difference of coarseness here and there, together with the angular and fragmentary state of the crystalline contents therein, which at the same time are not corroded, lend colour to the supposition that the rock is a volcanic ash composed chiefly of felsitic material.

Besides the general resemblance between Nos. $\frac{8}{467}$ and $\frac{70}{60}$ already alluded to, there is nothing but a distant family likeness between other boulder specimens and the few slides of Melani and other rocks sent me. The family likeness consists in the prevalence among certain specimens in both sets of rocks of a more or less pegmatoid structure. Identities of type are, however, wanting at present. We can gather therefore nothing more than a faint suspicion that the rocks of the Boulder bed were originally derived from the south, rather than from the north.

Subrecent *and* Recent Deposits *of the valley plains of* Quetta, Pishin and the Dasht-i-Bedaolat; *with appendices on the* Chamans *of* Quetta; *and the* Artesian water supply *of* Quetta *and* Pishin: by R. D. OLDHAM, A.R.S.M., F.G.S., *Superintendent, Geological Survey of India* (with one Plate).

Occupying a position intermediate between the highly disturbed tertiary and pre-tertiary rocks of the surrounding hills and the undisturbed recent deposits of the valley plains of Quetta, Pishin and the Dasht-i-Bedaolat, come the beds which were described as gáj by Mr. Griesbach,[1] and subsequently classed as siwalik by Dr. Blanford.[2]

Siwalik they may be as regards their age, using the term siwalik for all upper tertiary beds ranging in age from miocene up to the latest pliocene, but they must not be confounded with the true, or what may be called marginal, siwaliks of the outer hills. The contrast is especially striking owing to the close proximity of the two types; in the area intervening between the Bolán and Harnai routes to Quetta the hills are formed of siwalik beds, which extend continuously to within a few miles of the Quetta plain, and, throughout this area, they maintain a very constant structure. At the base there is often a small thickness of clean grey or greenish sandstones, with a few strings of pebbles or thin bands of conglomerate, but, with this exception, they show everywhere that increase in average coarseness of texture from base to summit, which is one of the most constant features of the true siwaliks. Near the base of the section the series is essentially an argillaceous one, the prevailing rock being a red or brown earthy clay; above this the beds gradually get more sandy, till sandstone is the prevailing rock and in this pebbles appear and gradually increase in abundance and size, till the uppermost beds are almost entirely coarse conglomerates.

The siwaliks of the valley plains differ radically in structure from these. Where exposed on the northern terminations of the Chehiltan and Mashálak ranges, the bottom beds are composed of angular or sub-angular debris of the same cretaceous and lower tertiary rocks as form the summits of these ranges; they are in fact identical in structure, appearance, and doubtless in origin, with the talus and fan deposits, which are at the present day being formed along the margins of these ranges. These beds are succeeded, without the intervention of any well-defined zone of medium grained deposits, such as sandstone, by fine grained clays and sandy beds. Where they have been disturbed and elevated, these have been cut into a network of low hills, absolutely bare of vegetation, and showing most conspicuously the bright colouration of the material they are composed of. Elsewhere, however, these beds tail off to a horizontal dip and cover a large area in the valley plains, extending continuously across the valley at Baléli, and abutting against the foot of the ridge pierced by the Murghi pass, where the relation of the high dipping cretaceous limestone to the horizontal red clays is evidently one of original contact. This, taken with the nature of the bottom beds in the Chehiltan and Mashálak ranges, makes it clear that these

[1] Mem., Geol. Surv., Ind. XVIII, 18.
[2] Mem., Geol. Surv., Ind. XX, 115.

clays have been deposited since the elevation of the mountains bounding the valley plains of Quetta and Pishin.

The siwaliks of the hills, on the other hand, are as clearly shown to be older than the elevation of these hills, not only by their forming an integral part of them and their highest peaks, but by the parallelism of stratification between the lowest beds of the siwaliks, and of the beds on which they immediately rest in unconformable contact. There is certainly a considerable lithological resemblance between the clay of the valley siwaliks and the clay zone at the base of the siwaliks of the hills, and it might be held that these were originally continuous and had since been separated by the elevation of the hills. On this supposition the junction of the valley siwaliks with the cretaceous limestone near Baléli would be a great faulted boundary, the faulting being concealed by a small thickness of subsequent deposits at and near the surface; such a supposition is just barely possible were there not weighty reasons for rejecting it. The most important of these is the impossibility of accounting for the absence of the great thickness of sandstone and conglomerate, forming the upper portion of the siwaliks of the hills, which must formerly have extended over the area occupied by the valley plains, and whose complete removal is inexplicable if their stratigraphical position were that of conformable superposition on the clays of the valley siwaliks. On the other hand, their thickness, close up to the limits of the valleys, shows that, in their original extension, these conglomerates and sandstones must have spread far beyond the present limits, determined by disturbance and denudation, over the area now occupied by the valley Siwaliks, and, as these latter cannot be older, the only alternative is that they are newer than the siwaliks of the hills.

The conclusion is strengtnened by a feature in the structure of the siwaliks of the hills. Instead of forming a single conformable system, they form two unconformable divisions, of which the older,—that which is referred to in the preceding passages,—was formed before the elevation of the hills and the great disturbance of the underlying beds; the other or newer, which is almost entirely composed of conglomerate, dating from a period when the older rocks had not only undergone nearly the whole of the disturbance they have been subjected to, but had been carved into deep valleys, and the present drainage system to a large extent already defined. The newer conglomerates rest with a marked unconformity on the eroded edges of the highly disturbed tertiary and cretaceous beds, as well as of the older group of the siwaliks. They can be seen in the Gandak or Sarakhúla valley, where their presence has been recorded by Dr. Blanford. They form part of the hills, east of Khánai, and an outlier of the same conglomerates forms the cap of a very conspicuous hill which rises above the railway line between Fuller's camp and the Bostán valley.

To the west of Khánai, the northern extension of the Bostán valley is bounded by a ridge whose surface is covered by a shingle of limestone and chert pebbles, evidently derived from the weathering of conglomerate beds. Owing to weathering of the beds and the absence of deep-cut stream gorges, no good exposures of rock *in situ* are seen in the conglomerate zone, but the contour of the hills, no less than the structure of the higher parts, shows that the dip of the beds is north-westerly, and

[1] Mem. Geol. Surv, Ind. XX, p. 185.

that these conglomerate beds graduate upwards, with a more gradual transition than in the Mashálak range, into the clay beds of the Pishin valley siwaliks. Now it seems natural enough to regard these conglomerate beds as closely related to those which unconformably cap the disturbed beds of the hills, east of Khánai and, as these are youngest beds of the siwaliks of the hills and the former the oldest beds of the siwaliks of the valleys, the relation between the two is evident.

It will be seen, from what follows, that these siwaliks of the valleys graduate upwards into the recent deposits of the valleys and that, in spite of local unconformities, the process of formation has been continuously going on in one part or other of the area under description. We have, consequently, another illustration of the two truths that are constantly being borne in on the geologist who works among the upper tertiary beds of extra peninsular India,—(1) that there is no real distinction or constant horizon of demarcation between the deposits of uppermost tertiary and of recent age, and (2) that in beds deposited subaërially in a region that has been undergoing disturbance and upheaval during the period of their accumulation, the stratigraphical value and signification of an unconformity is very different from what it has when found among beds of marine origin.

The siwaliks of the valleys graduate into the next type of deposit to be considered. In the Pishin valley the gently inclined siwaliks, which form the low range of hills lying between the head-quarters of the district and the broad Pishin plain, have a low westerly dip, which gradually flattens off to horizontal, and pass, with perfect transition, underneath a séries of fine grained, distinctly stratified, alternating beds, mostly thin, and varying from fine clay to fine grained sand. Very good sections of these beds are exposed in the vertical sides of the numerous nullahs which ramify through them, and especially in the high cliffs which border the bed of the Lorah, and their distinctly stratified nature proclaims them to have been formed by aqueous action, while the absence of anything that could be called a coarse grained deposit, and the rarity of even slight traces of false bedding, show that they must have been deposited in still water. In these features the beds bear considerable resemblance to a lake deposit, and, so far as their appearance is concerned, they might well be of such an origin. It is, however, very improbable that, with so small a catchment area, a large lake could be formed in the dry climate which appears to have characterized Balúchistán throughout the recent period of geology, nor are there any beach terraces, such as one would expect to find had the Pishin valley ever been occupied by a lake. But, though it is improbable that a permanent accumulation of water occupied any portion of the Pishin valley during the recent period of geology, it is more than probable that, before the outlet was deepened by erosion and so allowed the streams to cut deep channels through the plain, large areas of it were subject to temporary flooding after every heavy fall of rain on the surrounding hills. The water, as it left the hills, would carry with it debris of every degree of coarseness, but as soon as its velocity was checked, all the larger particles would be deposited, and the depression would be filled with water, bearing only fine particles of mud and sand in suspension. These, after a while, would subside, and the water would dry up, by the combined effect of evaporation and percolation, but the next flood would bring down a fresh supply of material to be deposited in a thin layer on the top of what had gone before.

The process here described can be seen at work on many of the valley plains of the Balúchistán hills and, as the lowest-lying parts are most often flooded and consequently receive the largest addition of sediment, one of its most conspicuous effects is a diminution of the surface gradients, till they cease to be perceptible to the eye. Now, in the Pishin plain, there is a very conspicuous difference in the surface gradients of the area occupied by these stratified deposits and that occupied by the unstratified loess which will be described further on.

From the foot of the hills to the east of the plain,—if we except a narrow zone in the immediate neighbourhood of the hills,—there is no perceptible gradient over the whole area occupied by the stratified deposits, but, from their limit, the loess rises very perceptibly to the north and west, to the foot of the talus slopes of gravel. This loess slope marks that portion of the plain which lay too high to be flooded, while the rest is the lower-lying portion subject to more or less frequent inundation, in which the gradient of the surface would be less, owing to that more rapid deposition in the lower levels which has been referred to above. It might, of course, be urged that the present extent of the loess marks the encroachments made by the dry land on to a pre-existing lake before it was finally drained, but, as far as the Pishin plain is concerned, the sections in the tributaries from the north, which join the Pishin-Lorah near Alizai, conclusively disprove this hypothesis. Instead of the loess being found overlying stratified deposits, we find that there is a horizontal transition from one to the other. The exact limit of each is not very definite and, to a certain extent, they are found to intercalate with each other, a distance of a quarter of a mile at places even of a couple of hundred yards, being sufficient for the complete replacement of stratified by unstratified deposits, thus showing that, during a period of time represented by the gradual accumulation of over 30 feet of deposit, the horizontal limit between the area which was liable to flooding, and that which was not, remained much the same.

In the foregoing description I have only mentioned the stratified deposits in the Pishin plain, but it must not be supposed that they are confined to it. It has been a matter of convenience to take Pishin as the typical area, because there good sections have been exposed by the streams, and there, owing to the red colour imparted to them by the river wash from the siwaliks, they are more easily recognized. In the closed drainage areas of the Dasht-i-Bedaolat and Gwende Dasht similar accumulations are being formed, but as they are composed principally of rain wash from the loess, and consequently more uniform in texture, the stratification is more obscure, while the absence of good sections, and more especially the identity of colour, renders it more difficult to separate them from the true loess.[1]

As seen in the Quetta and Pishin plains the loess is usually of a pale grey or yellow colour, fine grained in texture, firm enough to allow it to stand in perpendicular cliff of 50 feet or more in height, porous and readily absorbing water and very slightly permeable owing to the minute size of the pores. When broken down with water the loess forms an impalpable slimy clay which, in drying, retains the shape im-

[1] The term loess is here used, in the sense which it has acquired, to designate a fine grained deposit not stratified, or only obscurely so, of Æolian origin, the sense in fact in which it is used by the Baron Von Richthofen in his work on China, and without reference to any consideration as to whether it is or is not the same in age or origin as the typical loess of the Rhine valley.

pressed on it when moist, and is used for the manufacture of bricks of fair quality. In the composition of the loess there is always a considerable proportion of carbonate of lime, so that it effervesces freely with acid, and this is distributed evenly through the mass in the shape of minute grains, which are doubtless dust derived from the surrounding limestone hills. The other ingredients are equally minute granules of quartz and of argillaceous matter, the last enabling it to be used as a brick earth while the large proportion of lime renders it very easy to overburn the bricks. Small calcareous concretions, or *kunkur* nodules, occur, but they appear to be rarer than in the loess of China, and I have not been able to detect the numerous vertical tubelets which are described by Von Richthofen. In all other respects, both of texture, composition, structure, and in the contour of its surface, it agrees perfectly with the descriptions of that observer.

There can be no doubt that this type of deposit is really of Æolian origin; not only is the occurrence of finely comminuted limestone, most unusual, if not almost impossible, in beds formed by water but the absence of stratification points to the same conclusion. Moreover, if deposited by water, it must either have been formed at the bottom of a deep lake or in an alluvial plain. The shape of the surface would not be inconsistent with the former mode of origin, but there are no traces of those shore line terraces which could not but have been found had such a lake existed. Were the loess, on the other hand, a subaërial alluvial deposit, we would find a plain sloping gently in the direction of the stream, but nearly horizontal in a direction transverse to that, or even higher in the centre than at the sides; such, however, is not the shape of the section across the Quetta or Dasht-i-Bedaolat plain, where the lowest point is always in the centre, and the ground slopes upwards on either side towards the hills. The most conclusive evidence, however, is to be found in the widespread distribution, in height, of similar deposit, and its occurrence, in small patches, on the tops of hills and other places where an alluvial origin is quite out of the question.

In none of these beds have I found any fossils; the siwaliks and stratified beds of Pishin have not been very closely searched, but I have spent some time trying to find remains of shells in the loess. So far, all that has been found are some fresh-water shells, of the same species as are now living, in mud dug from some of the swamps in the valley. I was also shown a specimen of black clayey matter containing fragments of shells in a whitened and extremely friable condition said to have come from a depth of 60 feet in the artesian[1] boring put down in the Residency compound. The shells had been too much broken up by the boring tool to be determined with certainty, but there is no reason for doubting that they were fresh-water shells of existing species. The matrix was undubitably a swamp deposit, and apparently quite local in its extent, for it does not appear to have been met with in any of the other borings put down close by.

Of true fine grained alluvial deposits, formed by overflow of streams, as opposed to those formed in temporary stagnant accumulation of flood waters, there is little to be seen in the area under consideration. The streams all flow in narrow channels, cut below the general surface of the plain, and in the bottom of these

[1] The specimen was not seen by me till after the boring had been completed; no proper record of this well was kept, and the determination of the depth from which the specimen came depends merely on the memory of the driller in charge.

there are occasional stretches of alluvial land, but beyond this nothing. Coarse-grained gravel deposits are however abundant and conspicuous in the broad talus fans, which spread out from the mouth of every valley, as it leaves the hills. They are the often-described "fans" or "*Cones de déjection*," formed of water-borne debris of various degrees of coarseness, the actual slope of the surface depending on a variety of circumstances, the principal of which are the volume of water which pours down in flood time and the average size of the debris carried; it varies from about 300 feet to 600 feet per mile, slopes higher than this being found, but, I believe, in every case these are due to disturbance subsequent to formation. In the actual channels usually followed by the streams the gravel is tolerably clean and easily permeable, but over the greater area of the fan, where its surface is not now washed by the streams, the stones are mixed with a varying proportion of wind-borne dust, which may even completely obscure the underlying gravel and form a surface of pure loess. Sometimes, as on the north-east of the Quetta plain, the smooth glacis slope of the fan is separated from the hills by a region where the slope is steeper and where the gravels have been cut into an undulating surface intersected by valleys. The distinction of surface is very marked, and is difficult to account for unless we suppose that part of the fan has undergone disturbance, by which its surface has been thrown into a steeper slope than that at which the gravel is naturally deposited, and, in consequence, the water flowing off has been able to cut it into hill and vale.

Besides the gravels of the glacis slope or "Dháman," the streams push long tongues of gravel over the loess area and, as the streams from time to time have altered their courses over the fans, the direction of these tongues has varied accordingly and they have been successively covered up by the gradual accumulation of loess. One of these underground tongues of gravel formed by the Hanna stream can be traced near Sherdil, two miles from the edge of the gravel fan, where an area of some acres of ground is riddled with karéz shafts, some of which, lying along a well-defined line, have struck gravel, while others have found nothing but loess.

These stream deposits have been only cursorily described as they present no important features of interest or novelty so far as their structure or mode of occurrence is concerned. Economically, however, they are most important, for it is to the tongues of gravel that we must look for a supply of artesian water, while in the fans themselves is a source of water-supply which, when tapped by the karez, is a most important element in the agricultural economy of these valleys and of all the drier parts of Central Asia.

A digression regarding the theory of the karez.—As the theory of the karez is a matter on which much misconception is prevalent, it will be well to treat of it briefly. The ordinary explanation is that an "underground spring" having been discovered, a series of shafts connected by tunnels is made, by which the water is brought out to the surface. This idea of an underground spring is extremely prevalent and owes its origin to the description of the natives who have frequently told me that the water entered their karezes from springs. I have scrambled through the underground passages of some of these karezes to investigate the matter and have found, as might be expected, that the description is a natural but misleading one. In a few cases the karez does appear to derive its supply from what may without great

impropriety be called an underground spring. Such are the karezes between Kuchlák and Baléli which are driven through impervious siwalik clays up to the foot of a limestone ridge; it is not from the siwalik clays that they could derive any supply of water, so it is probable that there are here springs issuing from the solid rock. A still more striking instance is a short karez at Karáni driven, not into either of the fans which lie to the north and south of the village but towards the hill where there is no stream valley of any size, yet this is not only the shortest but one of the most abundant karezes I have seen: here, too, it seems probable that the water is supplied by a spring issuing from the solid rock. Such cases are, however, very exceptional, and, as a rule, the explanation, both of the real facts and of the origin of the misconception regarding the action of the karezes, is very different.

As the karezes are never lined in any way, it is impossible to drive them through incoherent material charged with water; it would moreover be unnecessary to do so as, if an incoherent bed of sand or gravel charged with water were once struck, the supply would amply satisfy the desires of the karez-diggers. The karezes, then, after they enter ground charged with water, can only be driven through stuff which is rendered coherent by a greater or less admixture of cementing material. But this cementing material not only renders the ground firm enough to form the sides and roof of the tunnel, but lessens the permeability of the ground and, what we are more concerned with, makes it irregularly permeable. When the karez is driven through such a deposit, the water will first of all drain away at those spots, where it is most permeable, very probably washing out the fine-grained matrix and forming a small channel penetrating to a greater or less distance from the sides of the tunnel. Into this channel water will percolate and, instead of oozing from the sides, enter the karez principally at certain defined spots, giving rise to what are called springs. The origin of the commonly held idea is thus natural and easily explained, but to call these "underground springs" is a misnomer and as misleading as it would be to apply the same name to an ordinary surface well.

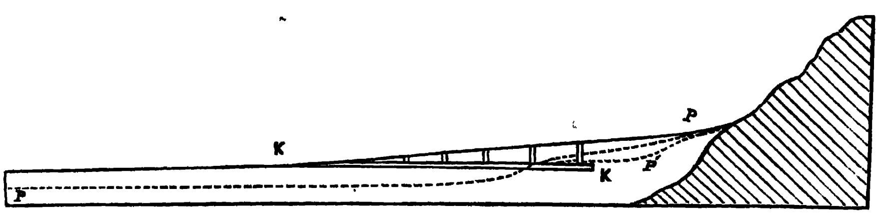


Fig. 1.—Diagram to illustrate the theory of the karez.

Having stated what is not, it is now necessary to describe what is, the correct explanation of a karez. In fig. 1 a diagrammatic section of one of the gravel slopes is represented; the dotted line *p.p.* represents the limit of permanent saturation, that is the limit below which the gravels are always charged with water even in the driest season. Such a limit exists everywhere, but the form of its contour depends on a variety of conditions, such as the rainfall, discharge of streams at the head of the fan, permeability of the gravels, etc., which need not here be considered in detail. Now, if the karez *k.k.* is driven into this slope, that portion of it which lies below the line *p.p.* will drain the sub-soil of its water and discharge this at the outlet.

It will be seen from this that in its nature and mode of action the karez is only a sub-soil drain; in both cases the object is to bring water which lies underground to the surface, the only difference being that in the one case it is desired to obtain the use, and in the other to get rid, of the water.

From the nature of the case these karezes are affected by the rainfall in a marked manner,—a single dry season, and still more a succession of years of deficient rainfall, causes a diminution in the discharge of the karez. Last year (1890) the falling off of water-supply was very widespread and, so far as the diminished discharge was only due to the dryness of the season, was not altogether an unmixed evil, for it led to an energetic cleaning out and in some cases lengthening of the karez which will improve its ultimate capacity. In a new karez, however, the failure may be due to another cause, which is more serious, as it permanently affects the supply of water, and may make this fall so low as to lead to the abandonment of the karez.

When the karez *k.k.* in fig. 1 is first made, water will flow freely into it from the surrounding gravels in all that portion which lies within the original limit of permanent saturation. But, after it is completed, a new outlet is provided for the sub-soil water, the limit of permanent saturation will adapt itself to the new conditions, and ultimately settle down with a profile which may be represented by the line *p. p'. p.* The subsequent history of the karez will now depend on the relative importance of the causes which led to the sub-soil water originally maintaining its level along *p.p.p.* If the gravels were tolerably permeable and a considerable supply of water was constantly percolating through them, the karez will settle down to a fair or abundant discharge. If, on the other hand, the amount of water percolating was very small and the level of permanent saturation kept up by the impermeability of the gravels, the ultimate conditions of the karez will be one of very small discharge.

I do not know to what extent this cause of failing supply of water has acted, or is acting, but there can be no doubt that, except in the case of old-established karezes, it must to a greater or less extent be at work. I made many attempts to collect information which would bear on this point, but was baffled by ignorance, reluctance to impart the information, or an inability, real or pretended, to understand the points regarding which information was desired. I was unable even to arrive at a trustworthy conclusion as to whether the reputed diminution of supply was as common, or as extensive, as was complained of, and this, when we consider how many reasons the proprietors have for complaining of a failure of water-supply and the absence of any inducement to acknowledge an increased discharge, is not to be wondered at.

As might be expected in a country where water is so valuable and apparently so mysteriously capricious in its occurrence, a class of men has arisen which pretends to a special knowledge of the underground distribution of water and to them the planning of new karezes appears to be principally entrusted. I have not met any of these men, but so far as I can gather they seem in some cases to possess a certain amount of knowledge, partly inherited, partly the result of observation, of the subject they profess. This is doubtless mixed up with a good deal of superstition, but as their directions are received with the same implicit belief as their rulers grant to the dictum of any self-styled "expert," the shaft, sunk on the spot indicated, is carried down till it reaches water, whereby the reality of his knowledge is proved.

Meanwhile he takes care to conceal the knowledge—if he possesses it—that there was no special virtue in the spot selected, and that there are many other places where a shaft would be equally certain to strike water, if given the same chance. Should water not be found, his employer is probably informed—for there is a close resemblance between the various species of the genus expert—that he did not go deep enough, or that though water was not found just there "the indications are very favourable," he is recommended to try some other place near by, and, if his patience or capital be exhausted before water is obtained, the expert, following the example of his kind, takes himself off to another country where his ignorance has not been exposed, there to find that ready credence which mankind is prone to yield to a plausible assertion of knowledge and, with better luck, repair his damaged reputation.

The amount of labour spent on some of these karezes, and the depth of their numerous shafts, is astounding; they are frequently miles in length and the shafts near their heads are said to be in some cases 150 feet deep. This is doubtless an extreme case, but, when examining the Quetta plain, I found that in many cases the shafts at the head of those which drain from the hills, east of the valley, could not be plumbed with the 70-feet line I carried with me. These must have taken many years and cost large sums to excavate, but it is probable that the whole was not made at once, and that they were gradually lengthened at their upper ends, where they are deepest out of the profits derived from the water which the original shorter channel yielded.

The Chamans or Artesian Springs of Quetta.

Among the most remarkable features of the Quetta plain are the numerous *chamans* or *chinnas*. The first of these words meaning a grassy spot, the second a spring, their nature is at once indicated. Riding across the naked plain, bare of vegetation where it is lying fallow or after the crops have been reaped, one suddenly comes on a green spot and water. Sometimes these are mere marshy spots, from which a small driblet of water may trickle away, but more commonly there is a pool, and not infrequently a strong spring of clear water issues from the soil.

There is a very conspicuous instance of this to be seen on the western bank of the Lorah just where it is crossed by the military road from Quetta to the Gháziáband pass. Here a strong spring of clear water with a discharge of several thousand gallons per hour issues from the scarped face of loess, as if from a rock. So too, about two miles from Quetta on the road to Sariáb, in one of these springs a short way west of the road, the water can be seen issuing with some force from the bottom of the pool. To the west of Quetta there is a series of these springs, draining one into the other and finally forming a considerable body of water, which has cut for itself a valley of some 20 feet depth in the loess. The great bulk of this water issues from the lowest of the springs, a pool of 20 feet diameter with a level bottom about 2 feet from the surface: this bottom is not, however, solid, but a very mobile quicksand kept in constant motion and surging to and fro by the action of a stream of water which is constantly forcing its way upwards from below. In 1888

a plummet was sunk into this, by Mr. P. Duncan, Executive Engineer, North-Western Railway, to a depth of over 100 feet before it was stopped, most probably by the friction of the sand on the sounding-line. From this it was evident that the water came from a considerable depth through a well-defined channel, and the nature of the spring stood confessed as a natural artesian well.

These springs vary considerably in size; from some there is a copious discharge of water, others again barely moisten a small patch of a few feet across, while yet another category is formed by those which, though they now have but a small discharge, show, by the sand heaped up over their orifices, that the water once issued with sufficient force to carry it up from below, the flow having since been checked by the falling in of the sides of the channel through which it flowed, by the heaping up of sand on the surface, or by both causes combined.

The most extensive of those belonging to the last category that I am acquainted with lies west of Quetta and covers about a couple of acres of marshy ground. Yet this is not a marsh of the type which is usually seen in the low-lying parts of valleys, where the level of permanent saturation rises to the surface, but it is distinctly raised above the level of the surrounding country, and on all sides water drains away in small driblets into the lower level of the loess plain. Between this and Quetta there is a very perfect little chaman, a low conical mound of about 20 yards in diameter, and rising some 4 or 5 feet above the level of the plain, at its apex, is a small pool of clear water and the whole recalls, on a very small scale, the description of the Hawaian volcanoes. Nor is the resemblance merely one of form, for there can be no doubt that just as these volcanoes have been built up of material poured out from the crater, so this has been built up of material brought from below by the water, which for some reason no longer issues with the force it used to.

Whatever may be the underground structure of the Quetta plain, the existence of water under pressure has been amply proved by the numerous successful artesian wells that have been sunk, but it still remains to be seen how the defined channels through the overlying deposits could have been formed before the "chamans" have been accounted for. In the case of those from which there is a copious discharge of water, it is conceivable that the channel might be kept open during the gradual accumulation of the loess, as any dust settling over the spring could be washed away as fast as it was deposited. In those far more numerous cases where there is little or no discharge such an explanation is not admissible, as there is no flow sufficient to keep the channel open against the continuous raising of the surface of the plain, and, in course of time, all these are certainly doomed to extinction; it might be urged that this is so, that these chamans which have so small a discharge were once copious springs, whose flow has been gradually reduced as the level of the surface was raised by the deposit of loess, and that the chamans, once much more abundant than they now are, have steadily diminished in number, as one after the other became obliterated by the same cause. The first objection to this is that, taking into consideration the great proportion of these springs whose condition is such that they would be obliterated by a very small increment to the thickness of the loess, small, that is to say, in proportion to the total thickness that has been deposited, and supposing that their destruction went on at the same rate throughout, the original number of the springs would have to be inconceivably great.

The most serious objection, however, is that the hypothesis is not a real explanation of the difficulty; as long as the water-bearing stratum formed the surface of the ground artesian conditions could not arise, and it is only after it had become covered up by a considerable thickness of fresh deposits that water could accumulate under pressure. Let us assume that only half the present cover was sufficient to produce artesian conditions, it is almost as difficult to understand how well defined vertical channels could have been made through 50 feet, of so necessarily homogeneous a deposit as the loess, as through 100 feet, and so we are landed once more in the same perplexity as before. Were it possible to suppose that these chamans marked the sites of old rock springs, whose flow had preserved an open channel through the gradually accumulating deposit in the valley, a natural explanation would be available, but the numerous borings put down at Quetta leave no doubt that such is not the case, that water under pressure exists below an extensive area, but that only locally and along defined channels does it obtain access to the surface.

The problem then is this, we have a permeable bed or beds containing water under sufficient pressure to make it flow at the surface as soon as it is afforded an outlet; we have overlying this a thickness of 100 feet or more of deposit homogeneous and practically impervious, except for certain defined channels reaching down to the water-bearing bed which can only have been formed after a considerable portion, if not to all intents and purposes the whole, of the deposit they penetrate had been accumulated. To account for these channels by natural causes seems impossible and the only resource lies in the hypothesis that they are the work of man, that the chamans in fact are in their origin artificial not natural artesian wells.

The idea, startling as it is, is not so absurd as it seems at first sight, the experience of the last two years has shown that the simplest and rudest appliances would suffice to put down a bore-hole through the fine-grained loess, and there are not wanting indications that the Quetta valley was once occupied by a race more civilised and energetic than the present indolent and apathetic inhabitants.

Scattered over the Quetta and adjoining plains there are a number of artificial mounds, varying in size, of which the largest and most conspicuous is the Miri, or citadel of Quetta. Owing to the earth from these being valued as a manure, some of them have been deeply dug into and they can be seen to be entirely of artificial origin and gradual growth; they are composed of innumerable layers of ashes and rubbish, mixed with earth, and have grown in size partly by the addition of material with deliberate intention of raising their height, but principally by the unintentional, steady raising of the level which goes on in every thickly populated locality through the constant bringing in of fresh materials for repairs to existing and the erection of new buildings. Originally they were probably the refuge forts for a race to whom the use of metals was unknown, but in their later stages they were occupied by a race which was not only possessed of the art of pottery, but made and used well-formed and well-baked bricks of a large size. Besides this, during the excavations made in the Quetta mound, Greek coins and a statue of Hercules were discovered, which show that the people who owned this fort 2,000 years ago had intercourse with the Western world. There is no great difficulty in supposing that this people possessed the art of boring for water, the difficulty is to understand how the art became lost, but an explanation may be found in the long

period of anarchy and internecine warfare which the country is known to have gone through.

The explanation mooted here has at least the advantage of accounting for the facts; it accounts for the existence of well-defined channels through the otherwise homogeneously impervious loess, and it also accounts for the differences in discharge from the different chamans. I have said that to bore down through the loess to the gravel beds is a task which can be accomplished with the simplest of appliances, but once the gravel is struck, to carry the borehole further would require appliances which we cannot suppose were at the disposal of these ancient inhabitants of the Quetta plain. Consequently the discharge from a borehole would depend on the nature of the first gravel bed struck. If the gravel were so mixed up with loess as to be quite or almost impervious, there would be no discharge, the well would soon fall in and become obliterated; if, on the other hand, the stuff struck immediately below the loess were freely permeable, the water would issue in large volumes carrying with it quantities of sand, as actually happened in the case of some of these chamans. Between each of these extremes every gradation might occur, as the greater or less degree of permeability of the water-bearing beds where struck, and the hydrostatic pressure of the water contained in it, admitted of larger or smaller discharge into and from the borehole.

Examples of both extremes of discharge can be found among the artesian borings put down during the last two years in Quetta. Two of these, put down by hand-power without any casing and carried only as far as the water-bearing bed, were sunk in the Residency Surgeon's compound; the first of these yielded a moderate flow of water, quite sufficient to keep the borehole clear, the second struck the gravel where it was less pervious and failed to give any discharge. The history of the pioneer well, that at the Railway station, is different. This was put down by steam-power with all the appliances which modern ingenuity has perfected. When the gravels were struck there was only a moderate discharge, but the well was carried on till, at a depth of 140 feet, a freely permeable bed was struck, from which the water commenced to flow, bringing with it large quantities of sand, till ultimately the well attained a discharge of 20,000 gallons per hour. Had this freely permeable band immediately underlaid the loess, the water, when first struck, would have issued with force, carrying up with it sand and loess washed from the sides of its channel, and doubtless ultimately have settled down to a copious spring of water similar to those referred to above.

Such is what appears to me the only feasible explanation of the chamans of the Quetta plain. That there are difficulties in the way I do not deny. It is hard to believe that the present race of inhabitants ever possessed the art of sinking artesian wells and we must look to their predecessors, a people who must have differed in character and may have been the same as those who built the "ghorbastas" of Sarawán, those extensive and carefully planned masonry works which have attracted the attention of more than one traveller, which also, like the artesian wells of Quetta, were intended to increase the agricultural capabilities of the land.

The restriction of these artesian springs to the Quetta plain, with the possible exception of one near Bostán, and their absence over the Pishin plain and Dasht-i-Bedaolat agrees very closely with the probable limitation of the area in which artesian water exists a a depth at which it would be accessible. At Bostán easily

accessible artesian water is known to exist, but the area over which it is likely to be found is very small and the pressure in the solitary boring put down was barely sufficient to make it flow at the surface. Under these circumstances it may be that one or two failures discouraged further attempts, or it may be that the pressure and flow of water was so small that boreholes, which once existed, have since fallen in. It must also be remembered that the sinking of these bore-holes with the primitive appliances available would be a work of time; the art may have originated or been most energetically carried on in the Quetta plain and, before the full capabilities of the other valley plains were developed, an irruption of barbarians destroyed at once the civilisation and the skill which had given birth to these undertakings.

This is, of course, a matter of conjecture impossible to substantiate, what is certain is that the chamans of the Quetta plain are essentially artesian wells, that the water rises by well-defined channels through a homogeneous and impervious cover from an underlying pervious bed, in which it exists under pressure, and that the bulk, if not the whole, of this cover must have been deposited before the passages were opened between the water below and the air above. These passages may have been opened by natural causes, but the most probable explanation, taking all things into consideration, is that they were made, with the deliberate intention, by a race the very memory of whom has now been forgotten.

On the mode of occurrence and probable distribution of artesian water in the valley plains of Quetta, Pishin, and the Dasht-i-Bedaolat.

In an attempt to decide whether artesian water exists under any particular spot, the first thing is to arrive at a definite conclusion as to the structure of the ground, and the cause of the pressure which makes the water rise to the surface when tapped by a borehole. The ordinary text-book explanation of an artesian well being inadequate and altogether inapplicable to the Quetta plain, it will be necessary, in the first place, to consider this question and then proceed to the application of the conclusion arrived at.

In the case of the Quetta wells the ordinary popular explanation is that the pressure comes from the surrounding hills, but a very slight consideration will show that there can be no continuity between the highly-disturbed ancient and indurated rocks of the hills, and the soft, nearly horizontal deposits of the plain which are still in process of formation, and consequently it is impossible in a general way that the pressure of the subterraneous water in the latter can be due to the greater vertical elevation of the former. There is, however, a particular circumstance of structure in which the pressure of the artesian water might come from the surrounding hills. If we suppose a subterraneous spring to issue in a patch of coarse-grained permeable deposits, *t. t.* in plate 1, fig. 1, such as one of the minor talus fans, and this patch of permeable deposits to be subsequently covered up and sealed by the deposit of fine-grained impermeable beds, *L. L.* of the same figure, there would be a small area in which a boring would be able to obtain artesian water, whose pressure would really be directly due to the water which soaked into the surrounding hills at a higher level. Such conditions are probably very exceptional, but the possibility of their occurrence must be borne in mind.

A more rational explanation of the pressure is that illustrated by the diagram section, fig. 2. This figure is analogous to the ordinary text-book explanation of an artesian well, on what may be called the basin theory, and in the case of the Quetta plain, such conditions do indubitably exist to a large extent. The rock basins in which the recent deposits of the Quetta and neighbouring plains have been formed are due to "earth warping," as it has been called, that is, to an elevation of the outlet of the drainage at a rate greater than the stream was able to cut downwards whence the velocity of the current was checked and deposits accumulated over a large part of the basin so formed; the first deposits being coarse-grained permeable stream gravels and sands which were afterwards covered up by fine-grained deposits. The exact proportion of the valley so underlaid by a floor of permeable grained deposits would depend on the rate of elevation of the outlet, and the original contour of the ground, none of which are now determinable with accuracy; broadly speaking, the floor of coarse-grained stream deposits will be continuous over the original main and tributary valleys, while the fine-grained deposits will be to some indeterminable extent in direct contact with the underlying rock on what were originally the spurs.

But though there is doubtless such a continuous floor of gravels, and though it is to this only that we can look for artesian water in the central parts of the valley plains, it by no means follows that this is the source of the artesian water that has so far been obtained, and a study of the records of the wells put down, as yet leads to a different conclusion.

The first artesian well in Quetta was put down in the summer of 1889. The next well in order of time to be sunk was that in the compound of the Political Agent, Quetta and Pishin, which also struck water and was followed by a number of others, particulars of which, so far as they are available, are given in the appendix. If all these wells have been sunk to a layer of porous deposit, which lies directly on the rocky floor of the valley and is overlaid by the finer deposits, we would hardly expect to find great differences in the depth at which they struck water, as the upper surface of the coarse deposits would be smoothed off to a fairly uniform slope by the action of the streams. But if we remember the tongues of stream deposits which are thrust forward from the main body of the fans over the surface of the fine grained loess, we can arrive at a simple and intelligible explanation. On this hypothesis the deep wells would penetrate the older tongues which, when the stream broke away from its course, became covered up by fine-grained deposits, till, at a later period, the stream again took a course approximating to its older one and formed the tongue from which the shallower wells derive their water. The conditions here indicated are graphically explained in the diagram section. fig. 3, which indicates a condition as favourable for the production of artesian wells as that in fig. 2, and is more in accordance with the facts at present known.

The only alternative hypothesis is the improbable, though not impossible, one that these wells have all been sunk on to lines of talus débris, and derive their water from a subterraneous spring, as is represented in fig. 1. Besides its inherent improbability, the nature of the gravel and sand brought up from the borings, so far as I saw it, does not favour this hypothesis. The pebbles were all more or less rounded and, especially the fine gravels, showed such signs of the action of running water that it is difficult to believe that they were not deposited by a running stream;

a supposition strengthened by the alternation of coarse and fine-grained material exhibited by the boring put down in the compound of the office of the Superintending Engineer, Sind-Pishin Railway. The question would soon be settled by a single boring carried down through the shallow water belt to the solid rock, or to the fine-grained impervious beds which should be found, if the explanation I regard as the more probable is the true one.

It would be too much to expect private enterprise to go to this expense, but seeing that nearly all the wells sunk, or being sunk, are Government wells, it does not seem too much to ask that one should so be driven on, even after water has been obtained, and if two or three others were sunk in properly selected spots in the neighbourhood of Quetta and driven as deep as possible, unless previously stopped by rock, a satisfactory conclusion regarding the true conditions of these wells will be arrived at. Nor would this be of merely theoretical interest—that bug-bear of the so-called "practical man"—but the knowledge so obtained, by enabling us to predict with some approach to certainty the probable result of boring for water at any spot, would result in a more economical expenditure and a prevention of the waste of money which will be inevitable if the principle followed is that of putting down a boring wherever it is thought that water would be desirable, irrespective of any considerations of the possibility of success.

In the meanwhile, it is impossible to determine with certainty the exact conditions under which the artesian water of the Quetta plain occurs, but the evidence available is so far in favour of the hypothesis I have suggested, illustrated by fig. 3, that I shall adopt this as the best working hypothesis available, and in the portion of this report which is devoted to a determination of the areas over which artesian water probably exists, shall base my conclusions principally upon it.

The Gwende Dasht and Dasht-i-Bedaolat have been least fully examined of any of these plains. They are both areas of closed drainage, both are remarkably level and characterized by an absence of large fans on their margins, the fine-grained deposits of the plains often extending right up to the foot of the hills. This absence of fans is due to the absence of any large streams draining on to the plains. and such small streams as do issue from the hills cannot extend far over the plain owing to the flatness of the surface. The recent deposits of both these plains seem, as far as could be judged when merely travelling along the road, to consist entirely of wind-blown loess, which has in many places a distinctly reddish tinge when wet. The lowest parts of these plains are, however, regularly flooded after heavy rain, and it is probable that there finely stratified deposits are formed, though, from the nature of the case, no sections can be observed.

The conditions here are altogether adverse to the occurrence of artesian water. The thickness of the loess is probably very great, and the coarse-grained beds which underlie it, have been cut off by its extension from any but a very small accession of surface-water at the margin of the plain. The very gentle surface gradients prevent the formation of long tongues of gravel extending into the plain, and the conditions of deposit to which the low surface gradients are due, have probably continued through the accumulation of some hundreds of feet of loess. The only part where there is any promise of success is in the extreme north-west corner of the Dasht-i-Bedaolat, where a larger stream than usual enters the valley, and there is a well-marked, though not very large, fan; a boring sunk a couple of miles

from the edge of this might find water, but I cannot regard the prospect as promising.

The watershed separating the Dasht-i-Bedaolat from the Quetta plain is formed by great fan-shaped accumulation of loess and gravel. This does not appear to me to be altogether a slope of deposit, but largely due to a warping of the surface in consequence of differential movements of elevation. However this may be, on crossing the watershed we enter a valley plain, which differs most markedly from the Dasht in the abundance of well-defined and extensive gravel fans, and in the distinctly noticeable slope of the surface towards the centre of the plain. The valleys of the streams within the hills are in many cases larger than those which drain on to the Dasht, and this, combined with the surface slope, enables them to send long tongues of gravel out into the plain. To this circumstance appears to be due the prevalence of artesian conditions in the centre portion of the Quetta plain, as evidenced not only by the successful artesian wells which have been sunk, but also by the numerous "chamans," or artesian springs, which are scattered over an area of seven miles from north to south, and three miles from east to west, in the central part of the valley. Over all this area, which includes the whole of the civil station and the western half of the cantonment of Quetta, water may be bored for with a probability of success; failure is, of course, possible in the sense that at any one particular spot the boring may miss the gravel tongues, and fail to find water at a depth which would make it worth while boring for.

To the north, along a sinuous line with a general east and west trend, about a mile south of Baléli, the red siwalik clays crop out at the surface and form a plain, rising slightly above the level of the loess, from which some low hills rise to heights varying up to about 40 feet. North of Baléli these siwaliks range right across the valley and abut against the hills on the east. Owing to the structure of these beds, artesian water probably exists under all this area, but at so great a depth as to make its extraction unprofitable.

About Kuchlák a strip of loess separates the siwaliks from the limestone hills to the east, and at its southern end is the fan at the mouth of the Murghi pass. Near this artesian water might be obtained, but it is doubtful, as the stream and fan both appear to be too small to produce the necessary conditions. A borehole was put down at Kuchlák village in 1890, but without success; failure, however, was only what should have been looked for here, as it is too far north to be supplied by the Murghi pass stream, and there is no other stream capable of producing the necessary conditions.

To the north of Kuchlák the siwaliks again extend across the valley and probably abut against the hills, though, at the surface, they are covered by talus. East of Bostán there is a large fan, whose southern margin runs on to the siwaliks, doubtless overlying them, and in this direction the chance of finding water is very problematical. On the northern slopes of the fan the conditions are different; here it tails off into loess, in which the presence of artesian water has been proved by the successful well sunk near the railway station. The area over which artesian water may be expected to occur, lies northwards from the village of Kasim Khán and east of the line of railway, but to the west of a line drawn from the village of Kasim Khán to the railway station, success is problematical, while north of the line of railway it appears to be impossible.

The Pishin plain is more extensive than any of the others and has not as yet been fully explored. All the eastern part of it is composed of finely stratified deposits, and over this area if artesian water exists at all, it is probably only at such a depth that it would not pay to bore for it. Along the northern and eastern margins of the plain, unstratified loess like that of the Quetta valley comes in, and there are several large fans of gravel. The resemblance in these respects suggests the possibility of a similar occurrence of artesian conditions, and I would suggest that experimental borings should be put down at about three miles from the edge of the Gulistán fan, in a south-easterly direction from the village, and at a similar distance south of the edge of the gravel fan at Alizai on the north of the plain.

It will be seen from the foregoing that the area over which water may be bored or with a prospect of suceess is much smaller than the expectations of those whose hopes have been raised by the successes at Quetta would lead them to suppose. It must of course be borne in mind that the conclusions have been based entirely on an hypothesis which is not the only possible, though the most probable one. But this is of the less importance as we are concerned principally with those areas over which water can be obtained at a moderate depth, deep borings being inadmissible from their expense where the water is required for agricultural purposes and only justifiable where special circumstances necessitate the procuring of a supply of water at whatever price it may cost. The area over which water can be obtained by borings of moderate depth would not be increased, but rather diminished from that described in this report, were any other hypothesis adopted than that on which I have based my conclusions.

SECTIONS OF BORE HOLES AT QUETTA AND BOSTÁN.

1. Well at Railway station—
   120 feet loess.
   20 feet gravel, underlaid by quicksand.
   Discharge 20,000 gallons per hour; hydrostatic head 50 feet.
2. Well in Political Agent's compound—
   115 feet loess.
   8½ feet shingle with a little artesian water.
   2 feet loess.
   Gravel, an abundant discharge of water.
3. Well in Loco. Superintendent's compound—
   92½ feet loess.
   3½ feet gravel with artesian water.
4. Well in Executive Engineer's (Railway) compound—
   90¾ feet loess.
   10 feet gravel, from which water just flowed at surface.
   10 feet loess.
   20 feet coarse sand and gravel, with an abundant discharge of water.
5. Well at Gymkhana—
   77 feet loess.
   10 feet "hard sandy stuff".
   8 feet "indurated sandy lumps".
   35 feet "clay with nodules".
   3 feet quick sand.
   12 feet hard clay.
   Quicksand with water.

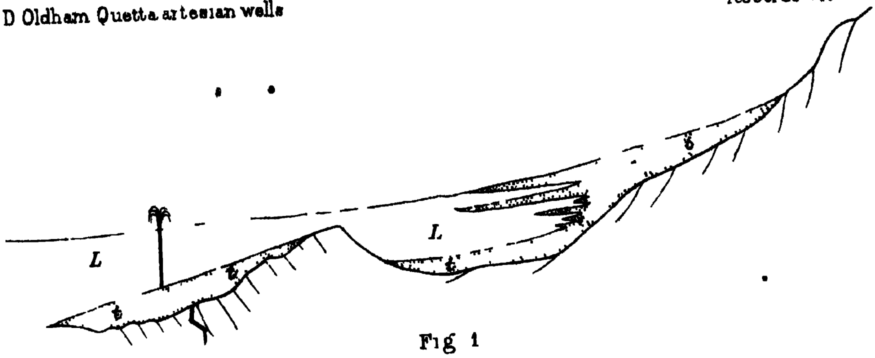


Fig 1

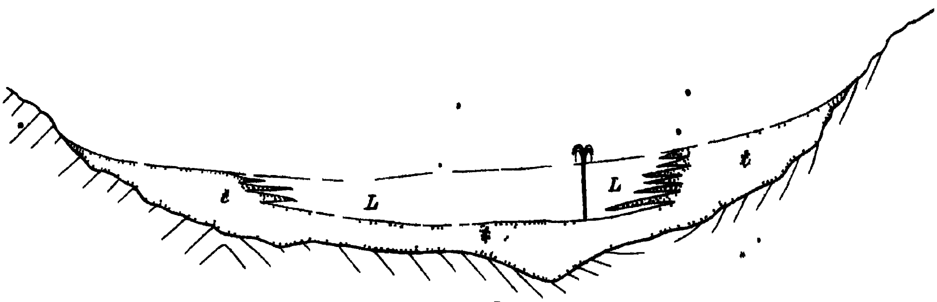


Fig 2

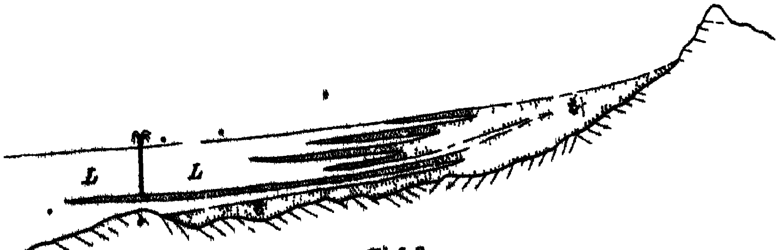


Fig 3

To illustrate possible conditions of occurrence of artesian water

L L fine-grained loess t t permeable gravels

6. Artesian well at Bostán, as determined from specimens preserved—
   10—20 feet pale yellow unctuous clay containing fine grains of silica and effernescing freely with acids. LOESS.
   20—30 feet the same, but not so fine grained.
   30—40 feet finer than 10—20 feet.
   40—60 feet very like 20—30 feet.
   60—80 feet the same with some pieces of calcareous rock, (kunkur).
   80—90 feet same as 10—60 feet.
   100 feet irregular small pebbles of pale grey limestone.
   180 feet still in gravel, discharge of water 2,500 gallons per hour.
   230 feet or thereabouts, entered as Siwalik clays.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

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Director's Office, Calcutta, 31st January 1892.

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W. B. DALLAS EDWARDS, A.R.C.S., Assistant Superintendent.
Sub-Assistant Hira Lal.
Sub-Assistant Kishen Sing.
Madras.—T. H. HOLLAND, A.R.C.S., Assistant Superintendent.
Head Quarters, Calcutta.—The Director; and R. D. OLDHAM, A.R.S.M., Superintendent.

Mr. Hughes and his party continue at the tin exploration in Tenasserim: Mr. Griesbach accompanied the north-east Burma Column, and afterwards joined the Irrawadi Column in quest of reported ruby occurrences. Dr. Noetling is attached to the Northern Column in the Amber and Jade country. Mr. Datta is engaged in surveying the country south of Yenangyoung. Mr. LaTouche, with Sub-Assistant Kishen Sing, has taken up the survey of the south-east Takht-i-Suleiman

frontier of the Punjab coal and oil series. Mr. Middlemiss and his party continue the survey in Hazara. Mr. Holland has visited the Chingleput, Malabar, Nellore, and North Arcot districts in connection with his collecting and noting on the iron ore tracts in Madras.

The Director attended the fuel conference at Quetta early in December, and fixed on sites for proposed experimental borings for coal and oil at Sukkur on the Indus. Mr. Oldham continues at the preparation of the new edition of the Manual of the Geology of India.

List of Reports and Papers sent in to Office for publication or record during November, December 1891, and January 1892.

Author.	Subject.	Disposal.
R. B. FOOTE . . .	Geology of the Bellary District.	Will appear as Part I, Vol. xxv. Memoirs of the Geological Survey of India.
J. W. GREGORY (British Museum).	The Jurassic *Echinoidea* of Kuch.	Will appear as Part I, Vol. II, Ser. IX, of the Palæontologia Indica.
P. N. BOSE . . .	1. The Igneous Rocks of Darjiling and Sikkim.	Record.
" . . .	2. On the elevation and disturbance of the Sikkim Himalaya.	Record.
C. L. GRIESBACH . .	Geology of the Safed Koh .	Will appear in the Records, Geological Survey of India, for May next.

Report *on the* work *done in the* Laboratory *of the* Geological Survey of India *during* November, December 1891, *and* January 1892; *by* Thomas H. Holland, A.R.C.S., F.G.S., *Geological Survey of India.*

1. THE CONVERSION OF ANHYDRITE INTO GYPSUM.[1]

Since the publication of my note on the specimens of "gypsum" collected by Mr. Wynne in the Salt Range, I have had the privilege, through the kindness of Dr. Warth, of examining the original specimen to which Mr. Wynne refers in his memoir as containing, according to Dr. Warth's analysis, 5 per cent. of water.[2]

The results I have obtained confirm in every respect the evidence obtained from the specimens in the collection of the Survey Museum; and, at the same time, explain clearly the suggestion made by Mr. Wynne as to the composition of the hard nodules in the Salt Range gypsum.

If the analyses of the hard nodules had given a constant result of 5 per cent. of

[1] A continuation of "Chemical and Physical Notes on Rocks from the Salt Range, Punjab," by the same author, Rec., Geol. Surv. of India, Vol. xxiv, p. 235.

[2] Mem., Geol. Surv. of India, Vol. xiv, p. 74.

water within the reasonable variations attributable to inaccuracies of experimental methods, Mr. Wynne's suggestion of the existence of a compound like "semi-anhydrite' would be a most natural one. But, whilst I find the specimen analysed by Dr. Warth contains, as he states, about 5 per cent. of water, that result is true *only for the portion of the specimen from which Dr. Warth obtained his fragment for analysis.* All other parts of the specimen exhibit variations in composition in the same irregular way as those already in the collection, and which I have described in my note.[1] If Dr. Warth had, therefore, taken a second fragment for analysis instead of repeating his experiments on the 1st piece, the results would have been widely different. The following results have been obtained in the examination of separate fragments taken from the original specimen analysed by Dr. Warth.[2]

Four fragments were broken off — two from the fresh surface from which Dr. Warth had evidently taken a piece for his analyses; the remaining two fragments were selected from other parts of the specimen.

The first two pieces, it will be seen, do not disagree greatly from Dr. Warth's analyses—

No.	Sp. Gr. (*determined.*)	Mineral composition. (*Calculated from Sp. Gr.*)		Chemical composition. (*Calculated from Sp. Gr.*)		Percentage of water *determined by ignition.*
1	2·762	Anhydrite . . .	70·2	Sulphate of lime . .	93·7	
		Gypsum . . .	29·8	Water . . .	6·3	5·37
2	2·752	Anhydrite . . .	68·6	Sulphate of lime . .	93·4	
		Gypsum . . .	31·4	Water . . .	6·6	5·21
3	2·659	Anhydrite . . .	53·8	Sulphate of lime . .	90·3	
		Gypsum . . .	46·2	Water . . .	9·7	8·40
4	2·612	Anhydrite . . .	46·4	Sulphate of lime . .	88·8	
		Gypsum . . .	53·6	Water . . .	11·2	10·02

A qualitative chemical analysis made by Mr. T. R. Blyth shows the rock to be composed almost wholly of sulphate of lime and water. Mr. Blyth has found no trace of magnesia, but carbonate of lime sometimes occurs in minute quantities. As in the results obtained during the examination of the other specimens, the water found by ignition is invariably less than that calculated from the specific gravity of the fragment.

I have examined, under the microscope, sections of Dr. Warth's specimen and

[1] Rec., Geol. Surv., Ind., Vol. xxiv (1891), pp. 235-44, and plates I and II.

[2] The method adopted is precisely that described in my former note (*loc. cit.*, p. 236)—the piece having its specific gravity first determined is crushed and *the whole* of the powder used in analysis.

they agree precisely with the description given in the previous number of the Records, of Mr. Wynne's specimens. Crystals of anhydrite, with characteristic cleavage and twinning, are imbedded in gypsum.

The same disposal of the constituents to produce an ophitic structure[1] characterizes the sections of this rock; and the same tendency to a schistose arrangement of the anhydrite-fragments, due undoubtedly to the hydration of the sulphate of lime, and coincident expansion to form gypsum.

Although I think there is now no doubt concerning the derivation of these gypseous masses from anhydrite, there seems no reason why the anhydrite may not have been simply de-hydrated gypsum. Upon this point the facts obtained in the laboratory can offer no evidence, and it becomes a question for the workers in the field to decide. I can only say that the gypsum is not of immediate sedimentary origin, and this agrees so far with the conclusions of Mr. Middlemiss as to the origin of the salt-marl.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of November and December 1891 and January 1892.

Substance.	For whom.	Result.
Coal, for assay . .	P. GISBORNE & Co., Calcutta.	Proximate analysis and calorific power determined.
4 specimens of quartz, for gold.	BARRY & Co., Calcutta .	Assayed for gold.
1 specimen of quartz, for gold.	Ditto . .	Ditto.
Coal, from Kasaullia valley, 2 miles east of Kalka, for assay.	C. L. GRIESBACH, Geological Survey of India.	Quantity received . . 8 lbs. Moisture . . . 1 24 Volatile matter . . 16·52 Fixed carbon . . . 37·82 Ash . . . . 44·42 100·00 Cakes strongly. Ash—dark red.

[1] In using the term "ophitic," I am aware of the fact that the ophitic structure of igneous rocks and the structure of these anhydrite-gypsum rocks are widely different in origin. The occurrence of a schistose arrangement of the anhydrite, together with this so-called intergrowth of 'ophitic' gypsum is worthy of note as an indication of the fact that the gypsum is younger than the anhydrite, being, in fact, derived at the expense of the latter mineral. A somewhat analogous arrangement is conceivable in an igneous rock: a basic magma with porphyritic crystals of felspar might be irrupted as a dyke, and, cooling under conditions of quiescence give rise to an ophitic disposal of augite around the minerals previously consolidated, whilst the felspars (*porphyritic*, of Rosenbusch) are arranged in directions parallel to the face of the dyke or direction of flow. Such a case I have described from amongst the rocks collected by Mr. Gowland in Korea (*Quart. Journ., Geol. Soc.*, vol. XLVII (1891), p. 185). Notwithstanding the points of difference in these structures, I do not feel justified in suggesting a separate name for the structure of the anhydrite-gypsum rock.

Substance.	For whom.	Result.
Quartz, with galena, for gold and silver.	BARRY & Co., Calcutta .	Assayed for gold and silver.
Alluvial earth, for gold .	J. T. BABONAU, Sub-Divisional Officer, Palamow.	Contains no gold—the shiningparticles referred to are minute scales of mica.
Quartz, for gold . .	BARRY & Co., Calcutta .	Assayed for gold.
2 specimens of quartz, for gold.	H. T. IVATT, Coonoor, Nilgiris.	Ditto.
2 specimens of minerals, for determination.	F. ANDERSON, Lohardugga .	Augite—large crystals. Magnetite, hæmatite, and titanoferrite in schist.

Notifications by the Government of India during the months of November and December 1891 and January 1892, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion, Reversion and Retirement.

Department.	Number of order and date.	Name of officer.	From	To	Nature of Appointment, &c.	With effect from	Remarks.
Revenue and Agricultural Department.	$\frac{2661}{8}$, Surveys, dated 10th December 1891.	R. D. Oldham	Deputy Superintendent, 1st grade.	Superintendent.	Substantive.	1st October 1891.	

Notification by the Government of India during the months of November and December 1891, and January 1892, published in the "Gazette of India," Part I.—Leave.

Department.	Number of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	Remarks.
Revenue and Agricultural Department.	$\frac{2584}{8}$, Surveys, dated 26th November 1891.	T. H. D. LaTouche.	Furlough .	24th May 1891.	7th November 1891.	

Annual Increments to graded Officers sanctioned by the Government of India during August, September and October 1891.

Name of Officer.	From	To	With effect from	No. and date of sanction.	Remarks.
	R	R			
T. H. D. LaTouche	620	660	1st April 1891.	Revenue and Agricultural Department, No. $\frac{2515}{35}$, Surveys, dated 21st November 1891.	
C. S. Middlemiss	580	620	1st November 1891.	Revenue and Agricultural Department, No 2497, Surveys, dated 18th November 1891.	
F. Noetling	620	660	1st October 1891.	Revenue and Agricultural Department, No. $\frac{2709}{36}$, Surveys, dated 17th December 1891.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph office.
T. W. H. Hughes	Mergui	Tavoy.
C. L. Griesbach	Bhamo	Bhamo.
R. D. Oldham	Calcutta	Calcutta.
P. N. Bose	Mergui	Tavoy.
T. H. D. LaTouche	Dera Ismail Khan	Dera Ismail Khan.
C. S. Middlemiss	Abbottabad	Abbottabad.
W. B. D. Edwards	Do.	Do.
P. N. Datta	Thayetmyo	Thayetmyo.
F. Noetling	Mogaung	Mogaung.
Hira Lal	Abbottabad	Abbottabad.
Kishen Singh	Dera Ismail Khan	Dera Ismail Khan.

DONATIONS TO THE MUSEUM.

FROM 1ST NOVEMBER 1891 TO 31ST JANUARY 1892.

2 specimens of asbestos, from Banswarra, Western Malwa.

PRESENTED BY RAGHONATH RAO YADOW BHAGVAT, SECRETARY, COUNCIL OF REGENCY, GWALIOR STATE.

Large sheets of mica in crystals, and sheets cut for the market, and smaller crystals of mica and pegmatite from Inikurti and Utkoor, Nellore district.

PRESENTED BY E. H. SARGENT, INIKURTI.

Crystals of garnet and apatite, from Nellore.

PRESENTED BY J. H. BROUGHAM, CONSERVATOR OF FORESTS, NELLORE.

ADDITIONS TO THE LIBRARY.

FROM 1ST OCTOBER TO 31ST DECEMBER 1891.

Titles of Books. *Donors.*

BLACKBURN, *Charles F.*—Hints on Catalogue Titles and on Index Entries, with a rough vocabulary of terms and abbreviations, chiefly from Catalogues, and some passages from journeying among books. 8° London, 1884.

DARWIN, *C.*—A Naturalist's Voyage round the World in H. M.'s Ship "*Beagle.*" 8° London, 1890.

DAWSON, *Sir J. W.*—Geology of Nova Scotia, New Brunswick and Prince Edward Island, or Acadian Geology. 8° London, 1891.

DITTE, *Alfred.*—Leçons sur les Métaux Professées à la Faculté des Sciences de Paris. Fasc 1. 4° Paris, 1891.

GEIKIE, *Archibald.*—Class-Book of Geology. 8° London, 1891.

GEIKIE, *Archibald.*—Outlines of Field Geology. 8° London, 1891.

GÜNTHER, *Dr. Siegmund.*—Handbuch der Mathematischen Geographie. 8° Stuttgart, 1890.

HEILPRIN, *Angelo.*—The Geographical and Geological Distribution of Animals. 8° London, 1887.

HETTNER, *Dr. Alfred.*—Gebirgsbau Und Oberflächenges taltung der Sächsischen Schweiz. 8° Stuttgart, 1887.

HOLMES, *Thomas Vincent* and SHERBORN, *C. Davies.*—A Record of Geological Excursions made between 1860 and 1890. 8° London, 1891.

KLEIN, *Dr. H. J.*—Jahrbuch der Astronomie und Geophysik. I. Jahrgang 1890. 8° Leipzig, 1891.

KUNTZ, *G. F.*—Gems and Precious Stones of North America. 4° New York, 1890.

LOCKYER, *J. N.*—Studies in Spectrum Analysis. 8° London, 1886.

MARCOU, *Jules.*—Autobiographical Notice of Ebenezer Emmons. 8° Pam., 1891.

THE AUTHOR.

MARCOU, *Jules.*—Geology of the Environs of Quebec, with Map and Sections. 8° Pam., 1891. THE AUTHOR.

Titles of Books. *Donors.*

NEHRING, *Dr. Alfred.*—Ueber Tundren und Steppen der Jetzt und Vorzeit mit besonderer Berucksichtigung ihner Fauna. 8° Berlin, 1890.

PRIEM, *Fernand.*—L'Evolution des Formes Animales avant l'apparition de l'homme 8° Paris, 1891.

RICHARDSON, *B. W.*—Diary and Life of Thomas Sopwith. 8° London, 1891.

SCHELLEN, *Dr. H.*—Spectrum Analysis in its Application to Terrestrial Substances and the Physical Constitution of the Heavenly Bodies. 2nd Edition. 8° London, 1885.

SOLMS-LAUBACH, *H. Grafzu.*—Fossil Botany, being an introduction to Palaeophytology from the Standpoint of the Botanist. 8° Oxford, 1891.

STEINHAUSER, *Anton.*—Grundzüge der Mathematischen Geographie und der Landkarten Projection. 8° Wien, 1887.

TRYON, *George W.*—Manual of Conchology. Vol. XII, part 49; and 2nd series, Vol. VI, part 25. 8° Philadelphia, 1891.

TYNDALL, *John.*—The Forms of Water in Clouds and Rivers, Ice and Glaciers. 10th Edition. 8° London, 1889.

PERIODICALS, SERIALS, &c.

American Journal of Science. 3rd series, Vol. XLII, Nos. 250-251. 8° New Haven, 1891. THE EDITORS.

American Naturalist. Vol. XXV, Nos. 294-296. 8° Philadelphia, 1891.

Annalen der Physik und Chemie. Neue Folge, Band XLIV, heft 2-3. 8° Leipzig, 1891.

Annales de Géologie et de Paléontologie. Livr. 9. 4° Palerme, 1891.

Annales des Sciences Géologiques. Tome XXI. 8° Paris, 1891.

Annals and Magazine of Natural History. 6th series, Vol. VIII, Nos. 46-48. 8° London, 1891.

Athenæum. Nos. 3334-3345. 4° London, 1891.

Beiblätter zu den Annalen der Physik und Chemie. Band XV, Nos. 4 and 8-10. 8° Leipzig, 1891

Chemical News. Vol. LXIV, Nos. 1660-1671. 4° London, 1891.

Colliery Guardian. Vol. LXII, Nos. 1603-1614. Fol. London, 1891.

Geological Magazine. New series, Decade III, Vol. VIII, Nos. 10-11. 8° London, 1891.

Indian Engineering. Vol. X, Nos. 14-24 and 26. Flsc. Calcutta, 1891. PAT. DOYLE.

Iron. Vol. XXXVIII, Nos. 975-986. Fol. London, 1891.

London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science. 5th series, Vol. XXXII, Nos. 197-199. 8° London, 1891.

Mining Journal. Vol. LXI, Nos. 2925-2936. Fol. London, 1891.

Nature. Vol. XLIV, No. 1142 to Vol. XLV, No. 1153. 4° London, 1891.

Neues Jahrbuch für Mineralogie, Geologie und Palæontologie. Jahrg. 1891, Band II, heft 3. 8° Stuttgart, 1891.

Repertorium zum Neuen Jahrbuch für Mineralogie, Geologie und Palæontologie für die Jahrgänge, 1885-1889, und die Beilage-Bände III-VI, Von. Dr. Leopold van Werveke. 8° Stuttgart, 1891.

Titles of Books. *Donors.*

Petermann's Geographischer Mittheilungen. Band XXXVII, Nos. 9-11. 4° Gotha 1891. THE EDITOR.

The Indian Engineer. Vol. XII, Nos. 234-244 and 246. Flsc. Calcutta, 1891. J. MCINTYRE.

GOVERNMENT SELECTIONS, REPORTS, ETC.

BOMBAY.—Brief Sketch of the Meteorology of the Bombay Presidency, 1890-91. Flsc. Bombay, 1891. METEOROLOGICAL REPORTER, BOMBAY.

„ Selections from the Records of the Bombay Government. New series, No. 202. Flsc. Karachi, 1891. BOMBAY GOVERNMENT.

INDIA.—Administration Report of the Baluchistan Agency for 1889-90. Flsc. Calcutta 1891. FOREIGN DEPARTMENT.

„ Administration Report of the Persian Gulf Political Residency and Muscat Political Agency for 1890-91. Flsc. Calcutta, 1891. FOREIGN DEPARTMENT.

„ Selections from the Records of the Government of India, Foreign Department, Nos. 278 and 280. Flsc. Calcutta, 1891. FOREIGN DEPARTMENT.

„ History of Services of Officers holding Gazetted appointments in the Home, Foreign, Revenue and Agricultural, and Legislative Departments, corrected to 1st July 1891. 8° Calcutta, 1891. GOVERNMENT OF INDIA.

„ List of Civil Officers holding Gazetted appointments under the Government of India, in the Home, Legislative, Foreign, and Revenue and Agricultural Departments, corrected to 1st July 1891. 8° Calcutta, 1891. GOVERNMENT OF INDIA.

of Officers in the Survey Department and in the offices of the Meteorological Reporter to the Government of India; Trustees, Indian Museum; Reporter on Economic Products; Director, Botanical Department, Northern India; and General Superintendent, Horse-Breeding Department; corrected to 1st July 1891. 8° Calcutta, 1891. GOVERNMENT OF INDIA.

Quarterly Indian Army List. New series, No. 9. 8° Calcutta, 1891. GOVERNMENT OF INDIA.

Report on the explorations of Sikkim, Bhutan, and Tbet. Flsc. Dehra Dun, 1889.

Statement showing quantities and values of Minerals and Gems produced in each British Province and Native State of India during the calendar year 1890. Flsc. Calcutta, 1891. REVENUE AND AGRICULTURAL DEPARTMENT.

TRANSACTIONS, PROCEEDINGS, ETC., OF SOCIETIES, SURVEYS, ETC.

BATAVIA.—Dagh-Register gehonden int Easteel, Batavia, vant passerende daer ter plaetse als over geheel Nederlandts-India Anno 1663. Van J. A. Van Der Chijs. 8° Batavia, 1891. BATAVIAN SOCIETY.

Titles of Books. *Donors.*

BATAVIA.—Notulen van het Bataviaasch Genootschap van Kunsten en Wetenschappen. Deel XXIX, afl. 2. 8° Batavia, 1891. BATAVIAN SOCIETY.

„ Tijdschrift voor Indische Taal—Land-en Volkenkunde. Deel XXXIV, afl. 6. 8° Batavia, 1891. BATAVIAN SOCIETY.

BERLIN.—Zeitschrift der Deutschen Geologischen Gesellschaft. Band XLIII, heft 2. 8° Berlin, 1891. THE SOCIETY.

BOSTON.—Proceedings of the Boston Society of Natural History. Vol. XXV, Part 1. 8° Boston, 1891. THE SOCIETY.

BRISBANE.—Annual Report of the Trustees of the Queensland Museum for 1890. Flsc. Brisbane, 1891. THE MUSEUM.

„ Proceedings and Transactions of the Queensland Branch of the Royal Geographical Society of Australia. Vol. VI, Part II. 8° Brisbane, 1891. THE SOCIETY.

BRUSSELS.—Bulletin de la Société Royale Belge de Géographie. Année XV, No. 5. 8° Bruxelles, 1891. THE SOCIETY.

CALCUTTA.—Archæological Survey of India. The Monumental Antiquities and Inscriptions in the North-Western Provinces and Oudh, described and arranged by A. Führer, PH.D. 4° Allahabad, 1891. THE NORTH-WESTERN PROVINCES AND OUDH GOVERNMENT.

„ Epigraphia Indica and Record of the Archæological Survey of India. Part VIII. 4° Calcutta, 1891. THE SURVEY.

„ Proceedings of the Asiatic Society of Bengal. No. 9. 8° Calcutta, 1891. THE SOCIETY.

„ Survey of India Department Notes for September and October 1891. Flsc. Calcutta, 1891. SURVEY OF INDIA.

CAMBRIDGE.—Proceedings of the Cambridge Philosophical Society. Vol. VII, part 4. 8° Cambridge, 1891. THE SOCIETY.

CAMBRIDGE, *Mass.*—Bulletin of the Museum of Comparative Zoology. Vol. XVI, No. 10. 8° Cambridge, Mass., 1891. THE MUSEUM.

DUBLIN.—Scientific Proceedings of the Royal Dublin Society. New series, Vol. VI, part 10, and VII., parts 1-2. 8° Dublin, 1891. THE SOCIETY.

„ Scientific Transactions of the Royal Dublin Society. Series II, Vol. IV, parts 6-8. 4° Dublin, 1891. THE SOCIETY.

EDINBURGH.—Scottish Geographical Magazine. Vol. VII, Nos. 10-12. 8° Edinburgh, 1891. SCOTTISH GEOGRAPHICAL SOCIETY.

FRANKFORT.—Abhandlungen von der Senckenbergischen Naturforschenden Gesellschaft. Band XVI, heft 3-4. 4° Frankfort-a-M., 1891.

GENEVA.—Mémoires de la Société de Physique. Tome XXI, part 2. 4° Genève, 1890-91. THE SOCIETY.

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 3[me] série, Vol. XXVII, No. 104. 8° Lausanne, 1891. THE SOCIETY.

LEIDE.—Annales de l'École Polytechnique de Delft. Tome VII, liv. 1. 4° Leide, 1891. L'ECOLE POLYTECH., DELFT.

LEIPZIG.—Wissenschaftliche Veröffentlichungen des Vereins für Erdkunde zu Leipzig. Band 1. 8° Leipzig, 1891. THE SOCIETY.

Titles of Books. *Donors.*

LONDON.—Journal of the Society of Arts. Vol. XXXIX, No. 2026 to Vol. XL, No. 2036. 8° London, 1891. THE SOCIETY.

„ Philosophical Transactions of the Royal Society of London. Vol. 181 A and B. With List of Fellows. 4° London, 1891. THE SOCIETY.

„ Proceedings of the Royal Society of London. Vol. L, No. 302. 8° London, 1891. THE SOCIETY.

„ Proceedings of the Royal Geographical Society. New series, Vol. XIII, No. 9. 8° London, 1891. THE SOCIETY.

„ Proceedings of the Zoological Society of London. Parts II and III. 8° London, 1891. THE SOCIETY.

„ Transactions of the Zoological Society of London. Vol. XIII, part 3. 4° London, 1891. THE SOCIETY.

„ Quarterly journal of the Geological Society. Vol. XLVII, No. 188. With List of Fellows. 8° London, 1891. THE SOCIETY.

„ Systematic List of British Oligocene and Eocene Mollusca in the British Museum. 8° London, 1891. THE MUSEUM.

MADRID.—Boletin de la Sociedad Geografica de Madrid. Tome XXXI, Nos. 1—3. 8° Madrid, 1891. THE SOCIETY.

MANCHESTER.—Memoirs and Proceedings of the Manchester Literary and Philosophical Society, 1890-91. 4th series, Vol. IV, Nos. 4—5. 8° Manchester, 1891. THE SOCIETY.

MELBOURNE.—Reports and Statistics of the Mining Department, Victoria, for the quarter ending 30th June 1891. Flsc. Melbourne, 1891.
MINING DEPARTMENT, VICTORIA.

OXFORD.—Catalogue of books added to the Radcliffe Library, Oxford University Museum, during the year 1890. 4° Oxford, 1891. THE MUSEUM.

PARIS.—Annales des Mines. 8^me^ série, Tome XIX, livr. 3 8° Paris, 1891.
DEPARTMENT OF MINES, PARIS.

„ Bulletin de la Société Géologique de France. 3^me^ série, Tome XVIII, No. 9, and XIX, No. 6. 8° Paris, 1889-90. THE SOCIETY.

„ Compte Rendu des Séances de la Société de Géographie. Nos. 16—17. 8° Paris, 1891. THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute. Vol. 132, Nos. 3—5. 8° Philadelphia, 1891. THE INSTITUTE.

QUEBEC.—Transactions of the Literary and Historical Society of Quebec. No. 20. Sessions of 1889 to 1891. 8° Quebec, 1891. THE SOCIETY.

ROME.—Atti della Reale Accademia dei Lincei. Série IV, Rendiconti, Vol. VII, Semestre II, fasc. 4—8. 8° Roma, 1891. THE ACADEMY.

ST. PETERSBURG.—Memoires de l'Académie Impériale des Sciences. Tome XXXVIII, No. 3. 4° St. Petersburg, 1891. THE ACADEMY.

SYDNEY.—Annual Report of the Department of Mines, New South Wales, for the year 1890. Flsc. Sydney, 1891.
DEPARTMENT OF MINES, NEW SOUTH WALES.

„ Proceedings of the Linnean Society of New South Wales. 2nd series, Vol. VI, part 1. 4° Sydney, 1891. THE SOCIETY.

„ Records of the Australian Museum. Vol. I, Nos. 8—9. 8° Sydney, 1891.
THE MUSEUM.

Titles of Books. *Donors.*

VIENNA.—Verhandlungen der K. K. Geologischen Reichsanstalt. Nos. 8 to 14. 8° Wien, 1891. THE INSTITUTE.

WASHINGTON.—Annual Report of the Board of Regents of the Smithsonian Institution to July 1889. 8° Washington, 1890. THE INSTITUTION.

WELLINGTON.—Reports on the Mining Industries of New Zealand, 1891. Flsc Wellington, 1891. MINING DEPARTMENT, NEW ZEALAND.

MAPS.

PARIS.— Carte Géologique détaillée de la France. Sheets 28, 80, 105, and 183. Map, Paris, 1891. GEOLOGICAL SURVEY OF FRANCE.

Govt. of India Central Printing Office.—No. 41 D. G. Survey.—10-3-92.—636.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1892. [May.

The Geology *of the* Saféd Kóh ; *by* C. L. GRIESBACH, C I.E., *Superintendent, Geological Survey of India.* (With 2 Plates of sections.)

CONTENTS:

Introduction.

During the field-season of 1890 to 1891 I was engaged in geological research in several areas along the north-western frontier, which structurally belong to the mountain system of the Saféd Kóh; the sections which I actually examined are partly within British territory, partly they are within tracts belonging to semi-independent tribes. These areas are separated by more or less unknown country and form patches, as it were, between the Miranzai frontier and the Kábul river valley. During part of the season I was deputed with the Miranzai Expedition commanded by Major-General Sir W. S. A. Lockhart, K.C.B., C.S.I.: after the conclusion of this expedition I proceeded to examine the oil localities east of Kohát. During the work I had naturally to take into account the experience I gained during my former visits to Áfghánistán, in particular the observations which I had an opportunity of making whilst in the Amir's service during 1888 and 1889: in the spring and summer of 1888 I visited certain parts of the Saféd Kóh and neighbouring ranges.

Literature.

Mention is made of the Saféd Kóh by nearly every writer on Áfghánistán, but practically scarcely anything is known of the geology of the main range, and the number of authors who touch upon

the geological structure or the mineralogy of this important mountain system is very limited.

The following must be considered :—

1. Captain E. E. Drummond, on the mines and mineral resources of Northern Áfghánistán,—Jour. As. Soc. Beng., X, pp. 74—93.

This author stayed for some time at Katasang in the Lógar valley during the first Áfghán war, and was thus enabled to examine the copper ore-bearing district of the neighbourhood, which belongs to the western spurs of the Saféd Kóh. He mentions the several formations which he came across during his excursions, without, however, going further into the question of the geological structure of the country he saw. His observations are quite correct, as I had the satisfaction of finding when I myself went over the country during my last stay in Áfghánistán.

2. Dr. A. Fleming, on the geology of part of the Sulaimán range,—Quart. Jour. Geol. Soc., IX, p. 346. Dr. Fleming mentions having found productus-limestone boulders in some of the streams (mouth of the Vidone defile for instance) which drain from the main range of the Sulaimán hills near the Takht-i-Sulaimán. Although this observation does not directly refer to the Saféd Kóh, it must still be taken into account, since traces of palæozoic rocks were also discovered within the area of the latter mountain system, the structure of which closely resembles that of the Sulaimán range in many important points.

3. P. B. Lord,—Jour. As. Soc. Beng., VII, p. 521, and India Review, III, 315. This author deals chiefly with the geology of the western parts of the Kábul province, but he mentions the existence of slates (Attock slates) from Attock on the Indus to the Kábul valley.

4. B. S. Lyman,—General Report on the Punjáb Oil-lands, Lahore, 1870. For a review of this author see Part IV of this paper.

5. H. B. Medlicott, on specimens sent by Major Tanner, Mr. Scott, Dr. Aicheson and Major Stewart from Afghánistán during the war of 1878 to 1880. See Proc., As. Soc. Beng., 1879, p. 176; 1880, pp. 3 and 123.

The most important of the notes by Mr. Medlicott are those on the rocks brought from the main range of the Saféd Kóh, and as these are the only observations in existence which deal with the central portion of the range, I have quoted this author's remarks *in extenso*.

6. Dr. Stewart, letters published in the Jour. As. Soc. Beng., XXIX, pp. 314 to 320, which mention geological observations which the author made during the operations in the Waziri country and which are important, as dealing with an area so close to the Saféd Kóh system. It seems highly interesting that Dr. Stewart had also met with a somewhat sudden change from the outer (eastern) tertiary belt to an area entirely composed of what appeared altered shales and rocks.

7. Major N. Vicary, on the geology of the Upper Punjáb and Peshàwar,—Calc. Jour. Nat. Hist., VII, 385; Quart. Jour. Geol. Soc., II, p. 260; and VII, pp. 38 to 46.

Major Vicary mentions having collected carboniferous fossils, a small

Spirifer, *Orthis*, *Terebratula* (?), and some *Polyparia* from boulders near the mouth of the Khaibar near Jamrúd. Pliocene beds (Siwaliks) he found to skirt the hills on the south side of the Pesháwar basin and to ascend even the valleys coming from the hills. The Buddhist caves in the Khaibar are excavated in pliocene rocks.

See also Dr. A. M. Verchère in Jour. As. Soc., Beng., XXXVI, p. 21, and Colonel H. H. Godwin-Austen, Quart. Jour. Geol. Soc., XXII, p. 29, who mention this find of fossils. The footnote on p. 500 of the "Manual of the Geology of India" discusses the subject.

8. Dr. W. Waagen, note on the Attock slates and their probable geological position,—Rec. Geol. Surv. India, XII, 183. In this paper the author discusses the probable age of the Attock slates, which form the easternmost spurs of the Saféd Kóh system. But far more important is:

9. by the same author,—Salt-Range fossils, Geological Results, Palæontologia Indica, Vol. IV., pts. 1 and 2, in which Dr. Waagen most ably discusses the geology of the Salt-Range system. Our former colleague had travelled from Pesháwar to the Indus, crossing the eastern spurs of the Kohát hills, and he has given an interesting account of the geology of this part. His views, however, closely affect the structural position of the Saféd Kóh, and I have therefore referred to them more fully further on.

10. A. B. Wynne, a geological reconnaissance from the Indus at Kushalgarh to the Kuram at Thal on the Áfghán frontier,—Rec. Geol. Surv. India, XII, p. 100.

Mr. Wynne had travelled over a part of the area described by me in this paper, and I shall have to refer to this author frequently in this paper. See also the same author in Records, Vol. X, p. 128.

I.—Notes on the Saféd Kóh and its skirting ranges.

Geographical features.

The Saféd Kóh (see pl. I) is a lofty mountain range which runs in a more or less east and west direction through part of the Kábul province of Áfghánistán, and which forms the watershed between the Kuram and Kábul rivers. This range, as commonly understood, may be said to begin in the Tiráh country of the Afridis and end in the Lógar (Lógard of the Áfgháns) valley north-west of the Shutargardan pass. This great chain is skirted on both sides by a series of more or less parallel ranges, which are often connected by vast spurs and a network of ridges. To the south of the main range extend the hills of the Kuram valley and of the Urakzai country, with the eastern prolongation of the Afridi and Kohát ranges, whilst north we find the hill ranges about Khúrd Kábul extending eastwards as the Jagdallak hills and the Siáh Kóh as far as the Doronta gorge west of Jalálábád; thence they are continued north of the Kábul river into Kúnar and to the Indus. These lines of ranges are connected by several intervening minor ridges and elevated areas, the geological structure of which is highly instructive, as it clearly shows that all these chains belong really to one mountain system. Although the main range of this system is well known to the frontier tribesmen and to most European geographers as the Saféd Kóh, which as an appellation is quite as precise as is the term Hindu Kush, nevertheless, quite recently

our most distinguished fellow-worker and master Professor Eduard Suess in his grand work "*Das Antlitz der Erde*," pages 552 to 574, expresses the view that the *western* Salt-Range, with all the ranges which lie between it and the Hindu Kush, is but part of a great system of mountain elevation of which the Hindu Kush may be looked upon as the most prominent feature.

I am not prepared to subscribe fully to this view, and I believe it will be found that the structural features of the area between the Hindu Kush and the Salt-Range, a large portion of which is occupied by the belt of the Saféd Kóh, do not entitle us to assume that this mountain tract south-east of the Hindu Kush belongs to the skirting ranges of the latter.

To a certain extent this seems also to be the view of our former colleague Professor Waagen, who reviews the structural features of the Salt-Range and adjoining regions in the Palæontologia Indica, Vol. IV, pp. 25 ff. He believes that Professor Suess is correct in considering the Salt-Range as the extreme southern margin of the Hindu Kush, if "we take the expression Hindu Kush as meaning the Hindu Kush system of elevation" (p. 29). And yet Dr. Waagen goes still further than Professor Suess, for he speaks of the spurs of the Saféd Kóh not only as belonging to the Hindu Kush system, but as the Hindu Kush itself, as for instance on p. 28, when he mentions the "low ranges" which "intervene between the Salt-range and the Hindu Kush"; unless the author understands as Hindu Kush the Saféd Kóh itself for instance, these "low ranges" must be the great mountain ranges of the Saféd Kóh and the ranges of Kafiristán, both which rise to over 16,000 feet height. Again, he speaks, p. 27, of the Sundully pass east of Pesháwar as being in the outskirts of the Hindu Kush!

I need hardly say here that no Indian Geologist or Geographer would admit for one moment the introduction of such a nomenclature. These various ranges have all well known geographical features, possess old established names, and to extend the name of Hindu Kush to any but the one range of precisely limited extent to which we now (see the article Hindu Kush in the Encycl. Brit.) apply the term would tend to hopelessly obscure the meaning of every work dealing with frontier geography. We in India even, to whom minor features of frontier geography may be as familiar as are suburban streets to a London postman, might be occasionally mystified, but, as a rule, readers in Europe would be hopelessly led astray if they were to search for the Sundully pass in the outskirts of the Hindu Kush! The "Sundully pass" is a saddle over one of the Kohát hill-ranges,—which, as I shall show further on, are off-shoots of the Urakzai hills,—and is in British India.

It will perhaps be best to review the orographical features of this part of Asia in a few words.

When travelling from the plains of the Punjáb to the wide-spreading alluvial plains of the Oxus, which form the most fertile parts of Áfghán Turkistán, the ancient Kafila road, along which the trade between Hindustán and Central Asia has been carried on for two thousand years or more, passes from Pesháwar to Bamián in a very nearly westerly direction over mountain ranges and valleys in succession. The first chain of hills so traversed is the well-known range known to us as the Khaibar pass; in reality it is nothing more than one of the north-eastern off-shoots [illegible]éd Koh. The latter extends in a more or less east to west direction and [illegible] wat shed between the Kábul and Kuram rivers. Its highest crest coin-

cides, roughly speaking, with the 34° latitude, but it is accompanied by more or less parallel ranges and minor ridges all connected together by a ramification of lower ranges. Its most easterly extensions are the spurs which run north of Kohát to east and north-east towards Attock. Similarly, the Samána range, with the hill ranges north of it, also belong to the system of the Saféd Kóh. From a purely orographical point of view this may readily be seen, and even natives of those parts know the close connection between the Saféd Kóh south of Jalálábád and the Kohát ranges. Continuous and forming one great orographical feature, this system of ranges could not fail to exert its influence even upon humanity, for since ancient times its slopes and valleys have been inhabited by races of close relationships, namely the unruly Afridis, Urakzais, Shinwáris, and others of near connection.

Beyond the Khaibar the great Kábul road passes mostly along more or less fertile valleys past Jalálábád to Kábul itself, crossing between Gandamak and Bút-khák the high land which links the Saféd Kóh system to the Siáh Kóh and the ranges north of the Kábul river valley, which are but the northern skirts of the Saféd Kóh. North and east of Kábul the traveller enters the mountainous country of the great ranges which traverse entire Afghánistán as an unbroken chain, with their subordinate off-shoots on both sides of the watershed. This latter may be said to begin in the highly elevated mountain ranges which bear generally the name of Pamir, of which there are several ; we really know too little of the orography of that region to be able to decide in what manner this mountain tract is linked on one side to the North-Western Himalayas, and on the other to the great watershed of Afghán-istán. If we follow the latter, it appears that after a very nearly east to west strike near the 37° latitude it assumes a more south-westerly direction till it reaches the mountain centre east of Bamián, within which the three river systems arise, of the Kundúz and Balkh drainage, the Kábul river system, and the Helmand, the latter which drains into the Seistán lakes. Now to this great watershed Eastern, as well as English Geographers have applied the name of Hindu Kush; by it is meant the watershed formed of the great peaks and chains between the Little Pamir and the Shibar pass, east of Bamián, and no other system of ranges, except the spurs closely connected orographically with it on both flanks of it. To extend the name to out-lying ranges, which have not even a common direction, *i.e.*, are not even parallel with the line of watershed here described and differ absolutely in their geological structure from that of the true Hindu Kush would only tend to hopelessly confuse all geographical expressions. I may here mention that the people of the country itself, living on the slopes of the Hindu Kush, really apply this name only to the passs Kótal-i-Hindu Kush between the Shibar pass and the Kótal-i-Chahárdar, but I found that Afgháns, in speaking in general terms of the great range which divides the Kábul province, Kafiristán and Chitrál from Badakhshán, do make use of the name of Hindu Kush. Westwards of Bamián the watershed remains strictly such, and may be traced right through Afghánistán into Persia, and is probably connected with the Caucasus and the Armenian systems. This watershed is not known to us by any one name, connected though the ranges are; immediately west of the Kótal-i-Shibar we know it as the Kóh-i-Bábá, which continues westwards into the water-shed of the Hazáráját. It is known south-east of Herát as Saféd Kóh, south-west of that city as the Dosházkh range; after which it passes into Persia, where the Elburz ranges form part of it.

Glancing at the excellent topographical map of Áfghánistán, as it is now available, we may perceive, that although all the mountain ranges of this part of Asia are more or less connected by minor ranges and passes, yet, strictly speaking, only the mountain chains and spurs which form the Upper Hazáráját (Upper Helmand), the Paghmán range, the spurs forming the Panjshir, Najrow, and Kafiristán valleys, with the spurs lying between it and the Kashmir borders can be looked upon as off-shoots of the Áfghán watershed. They in reality form the southern slopes of the Hindu Kush, into which the rivers have worked their way, producing the deep valleys of the Ghorband, Panjshir, the Kafiristán rivers, etc.

If we turn to the country lying east of Kábul, we find that the Saféd Kóh and Siáh Kóh ranges, with the Khaibar and Urakzai ranges, have an almost true east to west strike, and therefore form an angle of more or less 45° with the true Hindu Kush. Further south still we find the "Sulaimán" range with an almost due north and south direction at right angles with the Saféd Kóh and Siáh Kóh. If we compare, therefore, the Hindu Kush with the ranges intervening between it and the Indian frontier, and the latter again with the Salt and Trans-Indus ranges, we meet with great difficulties on the score of the absolute difference of direction of the respective system of ranges. That alone, however, need not be taken as a difference of origin of these ranges, particularly when the *bend*, not *break*, of the frontier ranges is taken into account, for we find the Sulaimán range break up north in the Waziri country into several knots and chains, and finally still further north turn round gradually into a north-east direction towards the Urakzai hills. Therefore it is quite possible to discover portions of the Salt and Trans-Indus ranges which might be looked upon o correspond in direction with these frontier ranges, although the strike of the latter would intersect the direction of the Hindu Kush proper.

On grounds of the orographical features alone I am absolutely against the extension of the term Hindu Kush to the ranges of the Punjáb, with which the former is not connected either structurally nor is the Hindu Kush even parallel to the latter.

Undoubtedly there are cases where local and popular names applied to orographical features may with advantage be exchanged for terms expressing more correctly geographical features, as for instance we have adopted in our books, and for ordinary usage, the term Himálayas for the great northern barrier of India, the word Himálayas originally only meaning the central portion including the holy peaks named in the *Vedas* and *Puranas* of the Hindus. But this northern barrier is so clearly a continuous range, or system of ranges, that it seems only natural, quite apart from geological reasons, to include the whole under one general name. But this cannot be said for the view, which looks upon the Salt-Range and the Punjáb frontier hills as out-skirts of the Hindu Kush.

Structural considerations.

In the classifying and re-naming, where advisable, of systems of mountain chains, we must be guided by either (1) purely orographical contours, parallelism of ranges or direct continuity of the latter, (2) by the more or less close relationship of the geological structure of mountain ranges to be compared, (3) by the fact that certain mountain ranges are found to owe their origin to the same causes, and are therefore more or less contemporaneous in formation, or, finally, (4) to a combination of first and common origin with geological and orographical features.

Let us shortly review the various mountain systems on and beyond our north-western frontier. We find at once that the Hindu Kush, Sulaimán range, Saféd Kóh (with outskirts), and the Salt-Range are neither directly continuous nor strictly parallel with each other; the Saféd Kóh and the Sulaimán range would both intersect the Hindu Kush if prolonged. Viewed, therefore, orographically only, it must be doubted whether these ranges can belong to the Hindu Kush system, whilst a closer examination of their geological structure reveals no proofs of their close relationships.

Geological history of the Central Asian area.

But the most important point to consider is whether these mountain chains owe their existence to a common cause, *i.e.*, whether they are of contemporaneous origin. If we look back into the past geological history of Asia we find that, after the close of the eocene epoch, vast changes have occurred in the western and central parts of this Continent. Resting on pelagic formations of limestone and beds containing nummulites and other eocene forms of deep-sea life, we find a long series of beds which point to a gradual narrowing and shallowing of the wide ocean, of which the so-called "jurassic mediterranean" was once part, and which continued long after and which reached in later cretaceous its greatest development. Fresh water and finally sub-aerial deposits follow on marine miocene, and so the process has continued up to the present day.

Such vast changes could only occur under conditions which would leave their imprint in the structural features of adjoining regions, and indeed this we find to be the case, not only in the vast folds which extend north of the great Perso-Áfghán watershed, but also along the north slope of the Central Himálayas and in the ranges which skirt the Baluchistán hills, the Sulaimán range, and the hills which form the frontier of North-Western India, including the Salt-Range,—not less than the Lower Himálayan ranges, which include the Siwaliks. Everywhere we find a hugely developed tertiary fresh water series resting on marine tertiary beds. The tertiary system in those regions shows invariably the traces of the vast changes which once have taken place, and which are amongst the latest causes of the elevation and folding of the strata into the hill-ranges which traverse Central Asia.

The principal disturbances took place after the deposition of the nummulitic formations over the entire Central Asian and North-West Indian areas, yet they were not absolutely contemporaneous, as the structure of the hill-ranges show, which fringe the Himálayan and Hindu Kush belts of elevation.

In considering shortly each area separately, it appears that:—

(1.) On both slopes of the Central Himálayas the marine eocene rocks are immediately overlaid by a series of littoral and fresh-water beds in which marine miocene fossils have not yet been found.

(2.) In the Salt-Range and in the hill-ranges of the Punjáb west of the Jhelum, including the hills which fringe the north-western frontier of India, miocene *Mari* beds have not yet been discovered; in fact, there also a great fresh-water series, which may possibly embrace all post-eocene beds, overlies directly the nummulitic strata.

(3.) It is not quite certain whether certain beds with marine fossils (chiefly corals), which are intercalated between the marine eocene beds and Siwaliks along the eastern skirts of the Sulaimán range may be looked upon as miocene; but further south a true marine miocene formation covers the nummulitic strata of Baluchistán (Blanford).

(4.) Turning to the Perso-Áfghán watershed, we find the miocene division of the tertiary system largely developed along the entire inner (Central Asian) margin of the Hindu Kush, Kóh-i-Bábá, Herát ranges, and in Persia. There we find a complete sequence of marine beds, into the upper miocene and in some sections, even into the upper tertiaries, followed by littoral, and, finally, by uppermost tertiary beds of fresh-water and aerial origin.

Hindu Kush still marine area during miocene times.

It is clear, therefore, that whatever causes contributed towards the folding and elevating process which formed these hill systems, the Himálayan, Salt-Range and Punjáb areas of elevation were already in existence in some shape, whilst the Hindu Kush area with the Perso-Baluch region was still covered by the miocene seas. Right in the very centre of the Hindu Kush and Kóh-i-Bábá range we find this marine miocene series, well developed, as for instance, near Bamián.

So far considered, the geological history of these ranges points to the fact that the Salt-Range with the Punjáb hills belong rather to the Himálayan system of flexures than to the Hindu Kush and its prolongation.

Crystalline area of Chitrál, etc.

But this is not all. The Hindu Kush, east of the Shibar pass to the little Pamir, with all the mountainous country to the south of it, including its skirting ranges in the Kábul district, Kafiristán, Chitrál, Dardistán, Gilgit into North-Western Kashmír with the hills of Dir, Şwát, and the country east of it, not less than the greater part of Badakhshán and countries north of it, comprising a known area larger than twice that of Switzerland, is chiefly formed of old crystalline rocks, amongst which there may possibly be some palæozoic outliers: this was land, when the partly littoral, partly fresh-water beds of the trias (with coal) were laid down in the basin of Kataghan and Áfghán Turkistán, and formed a rigid mass to a certain extent, against which the sedimentary formations of the mesozoic and tertiary times were forced and thus laid into the folds which form now the greater area of Central Asia and the fringing ranges north of the Hindu Kush. We see therefore that the flexures which form the Salt-Range are separated from those of the Hindu Kush by a wide belt which is an ancient area of elevation, and which is, in fact, the western prolongation, so to speak, of the great Himálayan crystalline belt, of which the "southern range, Central Himálayas" forms part, and which with the latter was already foreshadowed as a range, by a great "warp" or more or less elevated area, soon after or during the epoch when the Haimanta deposits were laid down along the northern margin, and perhaps in some areas within the belt of the Vaikritas of the Central Himálayas.

North-Western Punjáb ranges do not belong to the Hindu Kush system.

Considered, therefore, from either purely geographical, structural, or a causal point of view, I contend that the Salt-Range with the North-Western Punjáb hill-ranges belong rather to the Himálayan area of elevation than to that of the Hindu Kush, with which they do not seem to have any other connection than the more or less doubtful similarity of strike.

Where the old miocene coast-line might be drawn along our north-western and Baluchistán frontiers, and to the Bamián section, will have to be left to future research amongst the hill-ranges of Southern Áfghánistán and the Hazáráját probably; at present we must be content with the knowledge that structurally the hill-ranges of the Safed Kóh with the spurs running into British territory near Kohát belong to the

flexures which elevated the Himálayan and Punjáb ranges above the miocene seas soon after the close of the eocene epoch, whilst the region of the Western Hindu Kush and Kóh-i-Bábá was still covered by the miocene ocean, during which time and preceding it the ground which forms now the mountain countries of Kafiristán, Chitrál, Dir, Bajour, Swat, with areas extending far to the east, had been dry land from pre-tertiary times.

Our knowledge of the geological structure of the Saféd Kóh is at present limited to a few sections through the skirting ranges of it rather than through the main axis. The last observations which I have been able to make within the belt of this mountain system were taken this year whilst at work along the north-western frontier, and are embodied in parts II, III, and IV of this paper.

The following is based on notes which I was able to collect during my last stay in Áfghánistán when in the service of His Highness the Amir Abd-ur-Rahman Khán. I accompanied him on several journeys in the Kábul river and Kúnar valleys and was sent to examine geologically the Siáh Kóh, and the whole country of the western extremity of the Saféd Kóh, including all the mountain tracts of Kharwár, Logár, and Wardak.

Structural features.

It is with considerable reluctance that I publish these fragmentary notes on work which I had hoped to bring to a more fitting conclusion. Even within accessible regions of this great mountain system much remains to be geologically explored.

As already stated, there are three prominent orographical features (see pl. 1, sect. 3) which constitute the system of the Saféd Kóh,—

1. The main axis, commonly known as the Saféd Kóh.
2. The skirting ranges south of it, which extend south-west into the mountainous region of Kharwár, Gardéz, and Zurmutt, through which the system is linked, in some manner not exactly known, to the northern branches of the Sulaimán ranges.
3. The skirting ranges north of it, which are closely connected with the main axis near its western extensions and which continue eastwards as the Siáh Kóh, the Kúnar ranges, and, lastly, as the Khaibar ranges. How far these are connected with the ranges of Buner, Hazárá, and the Kashmir border, is at present difficult to say. I anticipate very important geological results when these areas have been studied in detail.

These three orographical features are strongly marked in the sections so far as known to us. The main axis, the Saféd Kóh, is least known to us geologically; it is probable, however, that the most prominent rocks composing it are of semi-metamorphic character, chiefly with schists and considerable intrusions of igneous rocks.

The southern ranges seem to be formed by sedimentary rocks, chiefly of mesozoic and tertiary age. North of this southern belt, and close to the southern slope of the main axis, I believe that a great dislocation has brought the mesozoic formations into abrupt contact with the metamorphic and sub-metamorphic rocks of the Saféd Kóh. They dip north as it were below the metamorphics of the main axis, whilst the contact is obscured by great intrusions of igneous rocks. Further east still, on the Miranzai and Kohát border, I found a series of anticlinals formed chiefly by mesozoic strata, flanked on the south by lower tertiaries, which latter are quite conformable to the former. The average dip of the sections is the same as in the

Shutargardan area, and generally varies from north-west to north-east, where nearest the main axis of the Saféd Kóh. I believe it is most probable that the entire belt of ranges which skirts the Saféd Kóh along its southern slope is cut off from the latter by a long line of fault or faults of a more or less east to west direction (see Secs. 1 and 3, pl. 1).

North of the Saféd Kóh, as I have shown, a system of ranges, the Siáh Kóh on the west and the Khaibar hills on the east side, runs more or less parallel with the main axis. The geological structure of this northern belt is more obscure in a sense than that of the southern slope of the Saféd Kóh.

It is quite probable that the fault or faults which have brought the mesozoic strata of the Shutargardan and the Miranzai border into abrupt contact with the metamorphic rocks of the main axis, are repeated on the north side of the latter by a system of dislocations parallel to the general strike of the ranges.

Direct proof of this supposition I have none; but it seems extremely probable, taking into account the structure of the sections as far as I have observed them and the appearance along lines parallel to the strike of the folds, of intrusive igneous rocks, which I believe have penetrated the sections along lines of dislocation.

The western and northern ranges of the Saféd Kóh.

The general structure of the sections through this northern belt is very similar in each case; highly altered strata, composed of shales and limestones often changed into metamorphic rocks are followed by metamorphic schists, which are again overlaid by a limestone series which has yielded traces of fossils, probably of carboniferous age, and which passes upwards into a succession of metamorphic rocks, chiefly a granitoid gneiss. There are evidences of faulting afforded by the appearance of igneous rocks (traps) along parallel lines both below the stratified rocks and north and parallel to it. That these traps are not interstratified I have convinced myself sufficiently, and I have come to the conclusion that these rocks have really been intruded along lines of dislocations.

The western sections through the northern range show a normally ascending series of strata—roughly speaking of metamorphic rocks both south and north, with two limestone series between them. The intrusive igneous rocks speak for the existence of lines of fault as already indicated, but to explain the structure, the section must be brought into comparison with the Khaibar hills (see secs. 1 and 3, pl. 1), when it will be seen that these northern ranges consist of a series of parallel and reversed folds, with several lines of dislocations (probably fold-faults) running in the strike of the flexures. It would thus appear that the younger series of limestones of the western end of the northern ranges is really represented by the series nearer the main axis. This view, I imagine, will eventually be found to be the correct one, when the state of the country will admit of a more extended geological exploration being made.

The main range.

Very little is known regarding the geological structure of the main range of the Saféd Kóh, except of that portion which ends in the hills east of the Lógar valley, south-east of Kábul. Of the highest portion of the range, which culminates in the Sikaram peak, little is known beyond what may be conjectured from a few specimens collected by officers during the last campaign.

In 1880 Major Tanner sent 12 specimens from the north (Gandamak) side of the

Saféd Kóh; whilst Mr. Scott, of the Survey of India, also forwarded a few from the summit of the Sikaram peak (15,620′) to Mr. H. B. Medlicott, then Director of the Geological Survey of India. Dr. I. E. T. Aicheson supplemented this collection by specimens from the southern, or Paiwar Kótal, flanks of Sikaram. Mr. Medlicot says regarding these specimens[1]:—

"From all these specimens we can form a rough idea of the geology of the ground. The ridge of the Saféd Kóh at Sikaram, and all the country to the north, seem to be formed of much altered rocks, though with only few samples of the extreme gneissic type. There is a remarkable preponderance (as represented by these specimens) of magnesian and calcareous rocks; amongst them some very fine white marble and steatite. The culminating point of the Saféd Kóh is approximately formed of pure white quartzite, but the range most likely owes its name to its snow-beds. The white rock from which Saféd Sang takes its name is a beautiful statuary marble.

"On the western flanks of Sikaram, at elevations of 10,000 feet, quite unaltered shales, with impressions of algæ, and similar rocks from the south side, occur among Dr. Aicheson's specimens. There are no observations to suggest what may be the stratigraphical relations of these highly contrasting series of rocks. The only clue as to age for any of these formations is a large pebble of limestone found in the Shalinár stream on the east side of the Paiwar Kótal; it is a lithodendroid coral, testifying to the presence of triassic or carboniferous strata in the vicinity.

"A serpentinous trappean rock or diallagic serpentine seems to be in force about Ali Kheyl."

Besides these specimens, Dr. Aicheson had also forwarded some rather poor copper ores, which had been found on the Karatega hill east of the Shutargardan.

Scanty as the information is, which is conveyed by these few specimens, it yet confirms the supposition that the main range of the Saféd Kóh consists chiefly of metamorphic rocks; this at least is the structure most probably of the main axis of this mountain system, as revealed in the ranges further west and south-west of the Sikaram, which Captain Drummond was the first to examine in 1838. I myself have had an opportunity of examining this ground in 1888 whilst deputed to Áfghánistán in the Amír's service.

The 69° 30′ longitude may be said to form as good a section as can, perhaps, be seen in these hills between the Kábul river valley and the ranges about the Shutargardan pass. It passes in succession through the three separate members of the Saféd Kóh system, namely the northern ranges, the main axis, and the southern skirting chains.

The road from Butkhák (11 miles east of Kábul) to Jalálábád ascends low ridges, chiefly formed of later tertiary conglomerates resting on schists and gneiss. The dip is rolling, and the strike more or less conforms to an east to west direction. About 5½ miles east of Butkhák the rock exposed in the hills north of the road is a hard grey limestone in flaggy beds, which has not yielded any fossils, but which, when marching from Kábul to Peshάwar in 1886, I believed to be part of the cretaceous limestone so extensively developed in Ághánistán: since then I have had the good fortune to see this section twice again, and am compelled to consider this view as scarce proven, and in fact there are strong reasons to doubt

[1] Proc. As. Soc., Beng., 1880, pp. 3 and 4.

that mesozoic rocks reach so far north as the Kábul basin. The dip of these limestone beds averages towards the north-west, but are much contorted and in fact show a dip to the south where the road passes the section some five miles east of Butkhák. The section seen between this point and Jagdallak itself is not very instructive. The limestone of Chinár (east of Butkhák) continues to the Lataband and east of it for some miles. It is associated in some manner not quite clear with metamorphic schists, amongst which micaceous strata seem predominant. The dip of the beds of the Lataband pass is almost due south, apparently, below the gneissose rocks whih are in strong force south of the Lataband.

The narrow gorge of the Kábul river north of this section and north of the Gogomand pass, the so-called Tangi Gháru, has been eroded through similar limestone, as far as I have been able to ascertain from the Amir's officials who were at work in the gorge constructing a road. The belt of this limestone must be some five or six miles wide, although I suspect that there are several distinct bands of limestone represented within a zone of metamorphic rocks, the limestone itself being in most places more or less altered into a very coarsely crystalline variety, containing mica. At Seh-i-Bábá, where the road crosses the valley, igneous rocks (serpentinous) appear. This outburst I believe to be north of the belt of limestone of the Lataband pass, whilst between Sei Bábá and Jagdallak the road passes again over metamorphic rocks, principally gneissose, which contain several horizons of a highly crystalline limestone.[1] The Pari Darra, that narrow defile within which a British force was destroyed in the first Áfghán war, shows the section through this series of rocks which are gneissose with some beds of mica schist and a wide belt of highly crystalline marble, the whole dipping under a high angle to the north.

The Siáh Kóh.

This chain of hills forms a well defined part of the northern ranges of the Saféd Kóh; and under the name Siáh Kóh, all the hills between the Pari Darra near Jagdallak and the Doronta gorge west of Jalálábád is understood. During the early spring of 1888 I was engaged in geologically exploring this system of ranges.

Its geological structure.

A section through the Siáh Kóh from south to north presents what appears to be an unbroken sequence of strata. Near the middle of the range, at Báb-i-Kach, a belt of considerable width (at that spot about six miles wide) is formed by a series of metamorphic strata, chiefly mica and hornblendic schists with talcose phyllites. Some beds of finely crystalline grey gneiss beds occur in this series, but on the whole the character of the zone is more schistose. This series is overlaid by highly altered strata, principally limestone beds, within which the old ruby mines of Jagdallak are situated.

The limestone belt is quite conformable with the underlying schists and, with them, has a rolling dip to the north and north-east.

The limestone belt may be traced across the Pari Darra (see above), from thence across the high Jagdallak hills, through which it takes an almost due easterly course to Amluk at the foot of a high crest, which rises in the Amluk peak to 7,790 feet; it runs from that locality always at the southern slope of the main crest of the Siáh Kóh to the Gachao peaks, south-east of which it crops out in the valley of the Súrkh-áb (river). It may be seen all along the scarp on the left side of the river

[1] See sec. 1, pl. 1

as far as the Doronta gorge of the Kábul river, and thence strikes across into the hills which form the Besúd and Kúnar ranges. This belt of limestone beds is economically important on account of the rubies which are found within it. They occur in a highly crystalline, coarse marble, which contains mica as accessory mineral; garnets and spinel occur with rubies throughout this belt, but at a few spots are accumulated in nests as it were, and then the entire rock is tinted a pink colour with the minute crystals of these minerals. With the schistose beds below the belt is closely connected both stratigraphically and mineralogically, several thin beds of crystalline limestone being seen inter-bedded with the mica schist below.

South-west of the Doronta gorge, near Kala-i-Sher, the section through the limestone is well exposed in most of the small ravines which cut through the scarp. I noticed that resting on the base of metamorphic schists are highly crystalline limestone beds in flags, with shaly partings: the limestone, though crystalline, has preserved its stratified structure perfectly. It is dotted with small rusty spots, which, I believe, owe their origin to decomposed garnets, which in other localities are common throughout the belt. Besides this it is highly characteristic of these limestone beds that white mica in small leaflets occurs in profusion along the plane of stratification throughout.

Limestone—fossiliferous.

Some distance higher in the section near Kala-i-Sher I observed some 40-50 feet of this limestone band almost unaltered and formed by dark grey hard limestone in which indistinct fossil impressions are visible with many fragments of *crinoids*. The whole appearance of the limestone reminded me much of the dark *crinoid* limestone of the Hindu Kush, which also is associated with metamorphic strata—a limestone which I have placed in the carboniferous system.

Carboniferous.

The beds above this fossiliferous limestone are much more altered, and are in fact converted into very fine white marble, fine grained and almost structureless. It is now being worked as a statuary marble by the Amir's people. Even in this marble isolated leaflets of mica are discernible, whilst higher up in the section the marble becomes very coarsely crystalline, which then contains much mica.

The entire thickness of the limestone zone cannot be less than about 3,000 feet in this section.

Ruby mines.

In the western sections through this limestone, garnets abound in the micaceous portion of the crystalline beds; and some 20 miles west of Tatang, rubies were found in the coarse varieties of this micaceous marble. The old ruby mines, which are being worked by the Amir, are situated in the crest of the Siáh Kóh about five miles west of Kardeathal. The rubies occur as accessory minerals along with great quantities of garnets in a micaceous coarsely crystalline limestone; as well as I could ascertain only in about 150 feet thickness of it. Regular mines there are not; the workmen, of whom there are about 300, irregularly quarry the rock wherever they see the red gems on the weathered surface of the limestone. The large blocks of rock so obtained are broken up by hand and the gems extracted with hammer and chisel, in which process of course many crystals are lost and broken. Minute crystals of rubies are exceedingly common, so much so that here and there nests of them colour the rock pink, but good stones are said to be rare.

Besides rubies, spinel is found, which the natives distinguish from the ruby.

Emeralds.

Emeralds are said to have been obtained, but I have not seen any of them myself derived from this locality. A large and good emerald was found in the alluvium of the Kúnar river a few years ago, and is now in the possession of the Amir. This stone may have come from the eastern prolongation of the same limestone belt.

It is strange that the miners have not attempted to wash for gems in the debris which is carried down by the hill streams into the Kábul river near the mines; I myself have found a small ruby of good colour in such debris.

This belt of limestone dips below massive gneissic rocks, hornblendic principally; the line of contact is nearly everywhere obscured by intrusions of syenitic granite which forms both the mass of the Amluk and Gachao peaks. The Doronta gorge of the Kábul river has been eroded through this gneiss and presents a very good section of it. The bedding is seen to be north-west about 40°, the strike being the direction of the range, as continued towards the Kúnar valley.

Eastern area.

One has, however, to proceed further east to estimate the structure of the Siáh Kóh fully.

The Kábul river runs near Jalálábád through a wide trough formed in recent and sub-recent formations, partly the enormous fans which extend from the main range of the Saféd Kóh northwards.

Sub-recent deposits of Háda.

Crossing the Jalálábád valley from north to south to the old village of Háda one passes over a wide expanse, formed of sub-recent and recent deposits. Immediately south of Jalálábád a few low hillocks rise above the level of the very fertile alluvium of the Kábul river; they are composed of gneiss with hornblendic granite intrusions. Garnets are found in both in large numbers, but especially in calcareous veins in the latter. About four miles south of Jalálábád the ground rises, and one ascends the northern limits of the extensive fan deposits which have spread themselves from the north slope of the Saféd Kóh into the valley of the Kábul river. Where the watercourses (dry during summer) have eroded their deep channels the beds forming this fan are well exposed. They consist of successive and irregular layers of loam (with sub-angular pieces of rock) and conglomerates, the latter often of enormous thickness. The present surface of this sub-recent formation is mostly covered in the depressions by a layer, more or less thick, of a breccia, here and there conglomeratic, the pebbles and debris of which are cemented together by a calcareous matrix, no doubt infiltrated by the flood and rain water, which at times overflows these fan deposits. The Áfgháns themselves call this hard deposit Ahinpósh (iron-skin).

Isolated hills of Jalálábád.

Out of this formation of recent and sub-recent gravels and clays protrude groups of high hills, which, if looked at closer, are recognized as remains of the rock-series which occupy the area between the line of the Siáh Kóh and the main range of the Saféd Kóh,—in fact, the eastern extension of the ranges which form the north slope of the Sikaram, and further west the hills about Khúrd Kábul. With the hill range of the Besúd area (north of the Kábul river) these hills south-east of Jalálábád form a continuous section and are structurally connected.

I found them to be formed chiefly of a highly altered series of slates and calcareous beds; amongst the latter of which highly crystalline limestone is found. Their

base is not seen, but they dip below the mica and hornblendic schists, which are *in situ* in the Besúd area north of it, and which form the Girdi Kach group of hills north-west of the Kóh-i-Bédaúlat. The isolated small hills south of Jalálábád which stick up through the surrounding alluvium, and which are formed of granitic rocks, evidently belong also to the metamorphic zone below which the Kóh-i-Bédaúlat slate and limestone series dip. The Kábul river near Jalálábád is marked by the appearance of igneous rocks, both granitic, as are the low hills south of Jalálábád and trappean, which are seen in the Girdi Kach hills along the river scarp. I think it highly probable that these rocks appear along a line of dislocation, and they form the eastern continuation of the Séh-i-Bábá outburst of trap rocks.

Hills north of Jalálábád.

The schistose belt may be seen also in the Bésud area, north of Jalálábád.

A low range runs from opposite the Doronta gorge in a more or less west and east direction, and is broken through by the Kúnar river which flows through the gorge Darra-i-Abdúlla Kheyl. A narrow saddle, the Tangi Pai Kóh, west of the Kúnar river, affords not only an easy pass into the Shéwa valley, but also a fairly good section through the strata composing the range. I found the rock to be a series of metamorphic beds, chiefly hornblendic gneiss, which is intersected and traversed by a complete network of largely crystalline granite; with the latter occur veins of pure white quartz and of pegmatite, all of which are more or less garnetiferous. Gold is said to have been found in some of these veins (reefs), but I did not observe any auriferous rock. The Besúd range is flanked near its western extension (opposite the Doronta gorge) by wide spreading sub-recent gravels and sands, which form undulating hills, and near the Kábul river, steep scarps. The range is crossed by several very rugged passes, used by sheep and their shepherds only; as for instance the Tangi Marúf Khéla near the western end of the range and the Kafir Darra further east. Both these defiles show similar sections.

Darra-i-Núr.

This valley joins the Kúnar valley from the right side, and formerly was one of the valleys belonging to Kafiristán. Large fans and sub-recent gravels fill the base of the valley itself and spread themselves over the wide basin of Shéwa, affording thus very fertile land for very extensive and terraced cultivation. The ranges which form both sides of the valley are entirely composed of metamorphic strata, chiefly gneissose, with granitic and trappean intrusions. Amongst the debris brought down by the stream are fragments of schistose rocks, which may be *in situ* higher up.

Laghmán valley, and area south of it.

West of this area, the Laghman valley comes down from Kalmán and Southern Kafiristán and joins the Kábul river. I ascended the valley for some twenty miles and found that the prevailing rocks which form the ranges enclosing the valley, are chiefly a hornblendic gneiss, in which there are numerous granitic intrusions. This formation I traced south into the Siáh Kóh, the entire north slope of which is made up of gneissic rocks with some subordinate schists. The Adrak Badrak Kótal in the Siáh Kóh leads over this rock series.

Summary.

Piecing these sections together, it would appear that we have the following divisions between the main axis of the Saféd Kóh and the Siáh Kóh systems:

In descending order:

5. Metamorphic rocks, chiefly hornblendic gneiss with granite.
4. A considerable thickness of limestones; traces of fossils. Probably carboniferous.
3. Metamorphic schists; trap intrusions.
2. Highly altered strata; chiefly calcareous.
1. Rocks of the main axis of the Saféd Kóh.

There are two horizons of calcareous strata; (2) represents one or more zones of chiefly calcareous beds, to which the Kóh-i-Bédaúlat section and the several calcareous and marble zones belong which are seen in the ranges south of Khúrd Kábul and in the Upper Lógar valley (see below), whilst the division (4) includes the fossiliferous and ruby-bearing limestone belt of the Siáh Kóh, which may probably be of carboniferous age.

So far the section between the main axis of the Saféd Kóh and the Kúnar ranges appears to be an unbroken and ascending sequence. The only feature which points to any fault or dislocation is the line of igneous rocks which appears between Lataband (Séh-i-Bábá) and the valley of Jalálábád.

Nevertheless, I believe that the section is not a normal one, but contains several very steep flexures reversed and with their longer shoulders dipping to the north. This would make the gneiss of the Siáh Kóh older than the ruby-bearing limestone zone (4).

To prove this assertion, however, I must refer to Chapter III, in which I describe the geological section through the Khaibar hills. The latter, I believe, forms the eastern prolongation of the northern range of the Saféd Kóh, of which the Siáh Kóh forms a part.

The western and south-western terminations of the Saféd Kóh.

The ranges near Kábul, namely, the hills which divide the Kábul and Chahárdéh valleys, with the Shir Darwaza and Asmai heights, consist chiefly of metamorphic strata, amongst which gneissic rocks are most prominent. Though locally much disturbed and considerably folded, this formation has an average dip to north-west, mostly under a very high angle. The same series continues in a south-east direction, and I found that the range which forms the left side of the Lógar valley north of Kata-Sang, and also the ranges on the right side of the valley, with the Shákh-i-Barant, belong to the same sequence of beds: a closer study of the latter was impossible at the time, but I observed that there was much folding and consequent repetition of the same series of strata. The prevailing types of rocks are: a hornblendic gneiss series and schists, amongst which true mica and garnetiferous schists are most common. Several bands of limestone, much indurated and here and there converted into marble, are intercalated; and some trap intrusions (melaphyre) appear at the eastern base of the hill range which forms the left side of the Lógar valley near Mián Khél and Hussain Khél.

Lógar valley.

The range which forms the right side of the Lógar valley near Kata-Sang shows the same structure. Drummond, in the Jour. As. Soc., X, p. 74, has given a short account of this range and the copper ores found in the neighbourhood, and I found his description of the rocks quite correct.

The pass of Silawat, east of Kata-Sang, leads over a semi-metamorphic band of limestone, rather slaty in places, which contains some mica, as does the Jagdallak ruby limestone; it passes in both directions into a micaceous schist, and I found the dip of the entire series to be from 60° to 70° N. W. by N., which dip remains the same with scarcely any variations in the hills east of the pass.

Khúrd Kábul and hills south of it.

I explored the Khúrd Kábul valley by crossing into it *viá* the Darra Zá Khél north-east of Kata-Sang. The rocks forming the hills of Khúrd Kábul are simply continuations of the mica schist with gneissic bands seen in the Lógar valley, dipping north-west: with it appear a few intercalated belts of highly altered limestone. The defile of Zá Khél passes through the latter, whilst masses of intrusive trap are met with further south-east near the Sis Tangi.

The hills south of Khúrd Kábul are so much disturbed that it would be extremely hazardous to say whether the grey compact limestone beds which form the Tangi Roján south of the Khúrd Kábul country are not part of the mesozoic limestone series of the Shutargardan; most probably they are. West of the limestone of the Tangi Rájan come masses of intrusive igneous rocks which have altered the limestone near the contact into marble.

The limestone band of the Kalagai hill south of Shád Khána in the Lógar valley certainly differs from the Tangi Roján limestone; I believe it is part of the altered limestone belt which, striking north-east, passes through the Latáband, thence east into the Siáh Kóh range; and, it may be, of carboniferous age.

Súrkh-áb.

South-west of the Khúrd Kábul valley I found again metamorphic rocks *in situ*. The range which forms the right side of the Súrkh-áb valley (near Padsháh Khán's forts) and north-west of the Shutargardan is chiefly formed of mica schist with clay slates. Some five or six miles east of Padsháh Khán's fort near the Súrkh-áb I observed that this metamorphic series is faulted against a limestone, which further north-east (in the Tangi Roján) is strongly developed. The locality (not on our maps) is where two side-streams, the Darra-i-Sar-i-Chasma and the Akhór Darra, join the Súrkh-áb valley: near this spot is a mill, called the Dégh-i-Asiá. The rock *in situ* near this point is chiefly mica schist, with which are associated beds of greenish grey phyllites and talcose schists, the whole system dipping north-west about 50° to 60°.

Limestone of the Tangi Roján.

The high hills to the north (Kóh-i-Sultán Áhméd Kabír) and north-east, in which the Tangi Roján (already noticed) is situated, consist of light grey limestone, very much disturbed and shattered in every direction. Just beyond the mill Dégh-i-Asiá a fault, very clearly seen along the hillside, has lowered the limestone to the level of the mica schist. Several minor faults accompany this dislocation and have brought wedges of this limestone within the belt of the mica schist. There is a considerable difference between this limestone and the many limestone bands which I have already noticed to form belts within the metamorphic rocks. Though I have no fossils from the Tangi Roján limestone, I believe I am correct in classing it with the limestone masses which form the Shutargardan and its adjoining country, and which are most probably of rhætic age.

This part of the section already belongs to the southern skirts of the Saféd Kóh which, as already said, is formed by a zone of chiefly mesozoic rocks.

We have seen that the highest crest of the Saféd Kóh (the Sikaram) consists of highly altered beds, and that there are metamorphic strata between it and the Siáh Kóh north of it. A glance at the map shows that the Sikaram forms a nucleus from which two main hill systems branch off,—one to the north-west, connected with the metamorphic rocks of the hills east of Khúrd Kábul; the other to south-west directly joined to the limestone (mesozoic) of the Hazárdarakht and Shutargardan area.

Contact between metamorphics and southern area.

How the mesozoic rocks of this south-eastern branch are joined to the metamorphic schists of the Saféd Kóh can only be conjectured, but the actual presence of a system of faults in the area east of Padsháh Khán and south of Khúrd Kábul (Tangi Rójan) seems to point out the probability that the contact between the southern area and the main axis of the Saféd Kóh is also a faulted one.

Further researches in these regions will have to decide this point and also whether my view is correct, namely that the north-western sections from the Saféd Kóh to the Kábul river correspond to the Khaibar sections, which latter form a series of reversed flexures (see pl. 1, sections 1 and 3).

The Shutargardan and Kharwár.

Much clearer were the sections south-west of the Shutargardan. A topographical survey which I had to make of the country between the Shutargardan and Ghazni for the Amír of Áfghánistán afforded me the opportunity of studying the geological structure of this area more in detail.

Fault.

A range of hills runs due south-west from the Shutargardan towards Shilghar, *en route* dividing Kharwár from Zurmutt and Gardéz. The north-western slope of this range of hills marks a line of fault, which I believe to be the south-western extension of the great Saféd Kóh dislocation, already spoken of above. Whilst I can only assume as probable the existence of such a dislocation in the central and eastern areas of the Saféd Kóh, it is here abundantly evidenced in the sections which may be seen along this line south-west of the Shutargardan.

This fault forms the most characteristic feature of the geological structure of this range of mountains. The entire area of Kharwár itself, with the exception of the south-east boundary range of it and the hills lying to the north-west of the Shutargardan, are formed of rocks other than mesozoic; the principal area being composed of crystalline rocks, probably of palæozoic age, with patches of tertiary deposits, whilst the area lying south and south-east of the line of fault is distinctly characterized by mesozoic deposits only.

This, as will be seen, is also the characteristic feature of the same line of dislocation in the eastern area (see Part II).

Igneous rocks.

Abundant intrusions of igneous rocks, chiefly basic ones, appear along the line of dislocation. Beginning near the Shutargardan, I found the Kótal-i-Shinkái, between Khúshi and Dobandi (west of the Shutargardan), composed of a porphyritic trap (melaphyre), which near the top of the Kótal contains inclusions of blocks of limestone, which are mostly changed into marble. It is the same trap rock which further north-east is seen to fill the area between the altered rocks of the main range of the Saféd Kóh and the sedimentary rocks of the Shutargardan area.

These trap rocks may be traced south-west for some distance; are again in great

force in the passes which lead from Kharwár to Altimúr; are seen at the base of the hills which bound the Khwája Angúr valley on the east side, and are strongly developed in southern Kharwár, where they occupy the boundary between the mesozoic rocks and the metamorphic palæozoic area.

Metamorphic rocks of Kharwár.

The north-western and principal area of Kharwár[1] is formed by metamorphic and sub-metamorphic strata. The description given of the rocks of the Siáh Kóh applies also to the older Kharwár formations. Gneissic and schistose rocks prevail, the latter containing some bands and irregular beds of graphite. Two distinct series of limestone beds are intercalated, which I believe to be the south-western continuations of the older limestone belts already noticed when describing the Lógar and Siáh Kóh ranges. They, along with the metamorphic rocks, are too much shattered and folded to afford clear sections, particularly as some granite intrusions have obscured the rocks still more by a good deal of contact metamorphism.

Metalliferous veins.

Near the lines of contact with the granite I noticed some metalliferous veins. Noticeable amongst them are (1) Carbonate of copper traces at the Kótal-i-Maulána (south of it); (2) Galena traces near Ursúk (southern Kharwár); (3) Galena (argentiferous) traces near Zanakhán.

The whole of this area of North-Western Kharwár, I believe, cannot be younger than carboniferous, and may possibly represent the entire palæozoic group.

It may be looked upon as the most south-western extension of the Saféd Kóh palæozoics; in fact, the range as such ends with the Kharwár hills, which lose themselves in the more open country south-west of it, the Ghazni district.

Tertiary rocks.

Tertiary rocks make their appearance there and overlap probably both palæozoic and mesozoic rocks unconformably.

Eocene (nummulitic) limestone and shales are *in situ* in the southern portion of Kharwár, where they form the hills over which the passes of Kótal-i-Ardá and Kótal-i-Ao-Dakái lead into Shilghar. They overlap the metamorphic rocks unconformably, and are cut off by the great Saféd Kóh fault from the mesozoic rocks south-east.

The deep valley of the Lógar river with its numerous tributaries has eroded the area connecting northern Kharwár with the older rocks of the Lógar ranges, which are part of the "north slope," of the Saféd Kóh. This wide area is now, as also the deeply-eroded centre of the Kharwár valley, covered over by the recent and sub-recent deposits and enormous fans, of much the same character as of the great Jalálábád sub-recent formations already noticed.

Very well seen are these deposits in the deeply eroded V-shaped valley of Khúshi, where a good section through the clays, shales, and conglomerates composing the formation may be studied.

Mesozoic series—(1) Kharwár.

South-east of the line of fault above described I found a belt of mesozoic formations, which are in abrupt contact with the metamorphic rocks of the Saféd Kóh and the igneous rocks which fill in the line of fault. Towards the south-east they are of unknown extent.

The range which bounds Kharwár along the south-eastern margin forms an

[1] Sec. 2, pl. 1.

almost straight line of scarp[1] running in north-east to south-west direction. Towards the south-east I found it sloped down in several undulating flexures, whilst a narrow zone of low hills (mostly of rounded contour) skirts the scarp along its north-western base. Two saddles lead over the range into Zurmutt—the Daháña Drang and the Kótal-i-Zintéga—and both afford fair sections.

I could only distinguish two divisions in the sequence of beds.

The low hills which skirt the north-west scarp are formed of earthy shales and sandstones, which are much altered near the contact with the intrusive traps which have filled up the line of fault already noticed. The shales and sandstones have a much disturbed, rolling dip, and they are so much crushed that it would be impossible to say to which geological horizon they might belong if it were not for a slightly less altered portion of this formation near the Kótal-i-Zintéga, which strongly resembles the fossiliferous beds of Dobandi, which I shall notice further on.

They are overlaid, probably conformably (but the beds are too much crushed to be certain of this), by strong limestones, which form the entire scarp from the Kótal-i-Altimúr to the Kótal-i-Zintéga. It is a hard grey limestone in thick beds, which shows traces of fossils on its weathered surfaces. The high rugged peaks overhanging the Daháña Drang are also formed of this limestone, which there yielded sections of *Dicerocardium* (?) and abundant *Lithodendrons* weathered out on the surface of the rock. Both these organic inclosures place the rhætic age of this limestone almost beyond doubt, and therefore the shales and sandstone beds below must be older, the structure of the section being evidently a normal one. Although these shales have not yielded any fossils in Kharwár itself, I venture to place them together with the sandstones in the upper trias or lower rhætic. In the Seighán valley, about 130 miles due north-west, the section through the upper trias (plant beds) and rhætic limestone reminds me much of these Kharwár beds, and, allowing for the great geographical separation, the two sequences are remarkably similar. In some of the Central Himálayan sections I have also found a series of earthy shales belonging to the upper trias overlaid by a great development of rhætic limestone, as indeed in nearly all the sections through the middle mesozoic marine beds in Asia with which I am acquainted. There are clear evidences of a great change in physical conditions having taken place at the close of the upper trias.

Such change of physical conditions must have taken place when the deposits in the South-Eastern Kharwár area passed from fine shales and sandstones into pelagic formations like the coral (*lithodendron*) limestones of Daháña Drang and the Shutargardan. This change is well marked and curiously corresponds with the features as observed in the Himálayas and in Áfghán Turkistán, and must mean widespread increase of ocean depths at the beginning of the rhætic period.

(2) Shutargardan.

The area of the Shutargardan is closely and directly connected with the Kharwár ranges. The nucleus of high points, consisting of the Shutargardan, the Machagáh, and the Saratéga, with its south-west extensions to Kharwár, are skirted along their western slopes by low hills, which are deeply eroded by a number of ravines. Structurally considered, the low hills are composed of a series of sandstones and shales, overlaid by the hard limestone formation of which the high peaks named are composed.

[1] Sec. 2, pl. 1.

West of this belt of sedimentary beds the traps described above have intruded along the great Saféd Kóh dislocation, and in the numerous faults which accompany the latter. Some of the softer beds of the shales and sandstones have suffered alteration: considerable areas having been converted into red brick-like rocks. The contact between the igneous rocks of Dobandi and the Kótal-i-Shinkái is remarkable for the veins of copper ore which are found along the contact zones. The shales and sandstones north-west of the Shutargardan are far too much shattered to give any but partial sections through them. They appear to form several very steep and crushed flexures, dip more or less north-west towards the metamorphic strata which are *in situ* on the other side of the great dislocation, and again dip below the limestone of the Shutargardan south-east of Dobandi. A continuous sequence, however, I was unable to discover within this much disturbed belt.

A deep ravine, with many side-streams, runs into the Dobandi valley near the village Shinkái, after pursuing a more or less south-westerly course. This, the Lóhazour (great ravine), cuts through the sandstone series. The beds seen in the valley dip about 70° W. N. W. and consist chiefly of calcareous grit with *belemnites* and *gasteropods*, alternating with sandstone which contains numerous plant impressions, too indifferently preserved for determination, and grey sandy shales. Thin seams of coal, none of them more than half an inch thick, are common throughout the series, and are well seen near the village of Shinkái. The whole series reminded me strongly of the upper plant-bearing formation of Turkistán and of the Saighán sections west of the Hindu Kush; I also believe them to be identical with the shales and sandstones of Kharwár, which, as shown, underlie the rhætic limestone. The plant-beds of Lóhazour are broken through by serpentinous traps and melaphyre; near the contact between the igneous rocks and the sedimentary series I found copper-ore traces. Some three miles north-east of Shinkái village, a low saddle leads into the Chinár Kheyl Darra, where I noticed a bed of dark needle shales, almost resembling Spiti shales, intercalated between the plant-beds, and they are traversed by a trap dyke, which has converted the plant-series near the contact into a semi-metamorphic schist. The dip of the shales is there about 50° to 60° N. W.

The dip increases as one follows the beds in a north-east direction; in the Jerobai ravine the needle shales are raised almost vertically and near Tangi about 80° N. W.

Thin seams (half inch) of coal are found throughout the formation, but are apparently all lenticular, often only carbonaceous traces along the bedding of the shales.

This plant-series dips below the limestone which is *in situ* at the head of the Dobandi valley, and which forms an undulating cap over the plant shales for many miles east and south-eastwards, associated with red beds near the base. The deep ravines which drain west into the Dobandi stream (Lógar valley) and east into the Kurum valley have cut through this limestone cap, and thus we find east of the Shutargardan, at the Sirkia Kótal, which leads into the Hazardarakht valley, again a section of plant-beds, conformably overlaid by the light grey limestone which composes the Saratéga and Karatéga hills. I believe it will be found that not only the Shutargardan, with the high peaks east of it, are formed by this limestone, but that this formation extends far east into the Kurum valley, and finally may take part

in the structure of a large portion of the Urakzai hills north of the country visited by the Miranzai Expedition.

I have not found any fossils in the limestone which overlies the plant-series of Dobandi; and the rather poor organic remains which occur in the latter have not been determined yet, but of the continuity of the Dáhána Drang rhætic limestone into the Shutargardan limestone, there can be no reasonable doubt whatsoever. This would place the plant-beds of Dobandi and the much altered shales and sandstones underlying the rhætic limestone of Kharwár into the same horizon, and both approximately into upper trias or lower rhætic.

The find of a limestone boulder with a lithodendroid coral in the Shalinár stream east of the Shutargardan (see page 78) would then assume further importance, for it seems almost certain that this boulder must have been derived from the Shutargardan rhætic limestone.

My observations extend no further towards the main range of the Saféd Kóh in this direction; between the east slopes of the Shutargardan and Karatéga and the sections through the Southern Urakzai hills there exists a wide gap, which I see no prospect of filling in for some time to come. What rocks may be found in this area one may only guess at; but a considerable similarity in the leading features of the western and eastern sections through the Saféd Kóh, and a great similarity, if not identity, between the sections of the Siáh Kóh and those through the Khaibar, which both form the northern skirting ranges of the Saféd Kóh system, may entitle us to form some idea what may be the structure of the central portion of the great range. I believe it will turn out that these intervening ranges form sections through the entire mesozoic group with, perhaps, a still more southern skirting belt of tertiary rocks, the whole separated, as it were, from the palæozoic series of the main axis by a long fault or series of faults.

II.—Geological Results of the Miranzai Expedition.

Area examined.

My geological reconnaissance of some parts of the Urakzai hills was limited to ground passed over during the progress of the Miranzai expedition in January and February of this year; this area comprises parts of three valleys, all inclosed within spurs of the Saféd Kóh. These are the lower (eastern) portion of the Khanki valley, the Sheikhán darra and part of the Zéra valley. The ranges inclosing these valleys skirt the main range of the Saféd Kóh, and are structurally and orographically connected with the latter; whilst the drainage flowing from these skirting hills belongs partly to the Kohát Towi, partly (the Zéra river) to the Peshāwar basin, namely the Bára river.

Strata dipping in northerly direction.

Viewed from any of the heights of the Miranzai district, south of the Urakzai country, it appears as if the area north of it were formed by a more or less uninterrupted sequence of strata, all dipping in a northerly direction. On nearer approach, however, this sequence of strata is found to consist really of a series of flexures, often reversed, which mostly show an east and west strike, but which are evidently frequently disturbed by faults, which have produced in some cases a "scale" structure, so often seen in areas formed by reversed flexures.

The former boundary between the Kohát district and the independent tracts

conformed to a large extent to the natural features of the country, *i.e.* it ran more or less along the foot of the Urakzai hills.

Geological structure.

A glance at section 3 of pl. 1 will perhaps better explain the geological structure of these hills than a mere description could.

The Lower Khanki river valley has been eroded more or less along the crest of an anticlinal. On the southern shoulder of it the tertiary series is seen to rest conformably on older limestones and quartzites which I look upon as cretaceous. Near the base of the Khanki valley itself lower limestones and fossiliferous beds appear, which may be possibly jurassic, but north of it follow again cretaceous rocks which form one or two much disturbed folds, within which (in the Sheikhán valley) some beds which are possibly jurassic appear. Beyond this point of the section the beds seem all to have a northerly dip and to consist of the same cretaceous and perhaps nummulitic formations, but, as I have not visited the more northern valleys, I am unable to decide how they are related to the Sheikhán and Samána ranges. The hills inclosing the Zéra valley (of the Bára river drainage) are still the same cretaceous rocks seen in the Samána range, but I fully believe that somewhere between the valley of the Bára river and the main range of the Saféd Kóh the feature will be found to be repeated, which I have described in the previous chapter as occurring in the Kharwár and Shutargardan areas, namely a well-marked dislocation, which has brought the mesozoic sequence of the southern ranges into faulted contact with the older rocks of the main axis of the Saféd Kóh. I trust the time may not be far distant when this question can be settled by a visit to this unknown zone.

List of formations.

I found the following formations present within the area examined during the progress of the Miranzai Expedition :—

(In descending order.)

1. Fans and recent gravel deposits.		
2. Olive and reddish brown clays	. . . . . .	Eocene.
3. Limestone with nummulites	. . . . . .	Eocene.
4. Hard white limestone .	. . . .	Nummulitic?
5. Grey limestone; fossil traces	. . . . . .	Cretaceous.
6. Quartz sandstone series	. . . .	Cretaceous.
7. Limestone and shales with fossils	. . . . . .	Jurassic?

Jurassic rocks?

Near the base of the Khanki (valley[1]), on both sides of it near Gwada and below it, I found a series of hard grey limestones, with a few partings of shales, and near its upper limit, of quartzitic beds, which series has yielded some few fossils, chiefly *brachiopods* of jurassic type. This division seems fairly rich in fossils, the traces of which may be seen on the weathered surfaces of the rock, and had I been able to stay there longer, it might have been possible to make a better collection; as it is, the specimens are not sufficient in number and good enough in preservation to determine their age with certainty. But I think it very probable that they are not younger than upper jurassic.

Similar beds crop out at the base of the cretaceous rocks in the Sheikhán valley (west of Laghardarra), where they are associated with soft earthy shales of greenish

[1] See pl. I, sec 3.

grey colour; the limestone beds there contain *brachiopods*, but not the shales which are strongly developed in the narrow valley in which Mirchina is situated.

The beds immediately above the fossil-bearing limestone of Gwada consist of a hard, grey to faintly pink quartz sandstones with calcareous beds and grits.

Cretaceous; Quartz-sandstone.

The quartz-sandstone is often spotted with ferruginous markings (decomposed garnets?), and, as far as I found it, unfossiliferous. Its thickness I have not been able to estimate, as most of the hillocks were too much covered with snow during my stay in that country to permit a closer study, but it is probably not less than two or three hundred feet, if not more. It seems to vary a good deal in thickness; so, for instance, its thickness is much greater in the section north of Gwada than in the Samána range. This division reminds me a good deal of the quartz-sandstone of the Takht-i-Sulaimán range, where it forms the lower cretaceous, overlying what I believe to be upper jurassic beds.

This quartz-sandstone appears also immediately above the *brachiopod* limestone west of Laghardarra in the Sheikhán valley, and I have seen it near the top of the pass which leads from Bar Marai to Zéra in the Stúri Khéyl country, but in both localities I was unable to distinguish it on the map, as the boundaries were too much obscured, and my stay too short to record them on the map.

The upper beds of the cretaceous system of the Urakzai hills are formed by a series of strata amongst which a grey hard limestone is most prominent. In lithological character it does not differ from most of the hippuritic limestones so common throughout the Perso-Afghán area. Beds of shaly limestone and of quartz-sandstone, especially near the base of the division, are common. Fossil traces are seen on the weathered surfaces, but I obtained nothing which might be determined. One fossil fragment, possibly of a *hippurite*, I found on the Samána range.

Limestone; Upper cretaceous.

The greater mass of the Samána range, the hills north of it, and also the Star-ghar range is apparently made up of this upper limestone, but it is quite possible that part of it belongs already to the next higher horizon.

The great mass of the Mazjogha (7,890′) is composed of beds dipping about 20° N.N.W., and as far as one may venture to guess, is chiefly made up of cretaceous strata, the western continuation of the Starghar range.

Rocks of tertiary age I found only along the southern skirts of the Samána range, therefore in British territory. The beds resting conformably on the upper cretaceous grey limestone of the Samána range are hard white limestones, which are intimately connected with the strata directly overlying them, and it seems therefore best to include them with the latter amongst the eocene (nummulitic) rocks. Resting on these hard limestones, I found hard limestones, generally light coloured, which yield in abundance *nummulites* and traces of corals. They are overlaid by softer beds, containing also *nummulites*, amongst which earthy greenish grey, sometimes olive coloured clays and soft shales are commonest. They are associated with red beds, which form a large area in the Kohát district. South of this eocene section, near Darband, the area examined by me adjoins the sections described by Mr. Wynne[1] who has made out the succession of the tertiary series in the Kohát district.

Eocene.

[1] See Records, XII, p. 100 ff.

Fans and recent gravels.

All the valleys within the Urakzai hills possess extensive accumulations of sub-recent deposits of gravel and fans, which may especially be seen largely developed in the Samilzai tributary valleys of the Kohát Towi. The terraces on both sides of the Gorbin river (higher up the Khanki stream) near Shew-Kheyl (Shew, on the map) expose these fan deposits very excellently.

They are mostly made up of rolled fragments of rocks of the near neighbourhood (cretaceous and nummulitic), with irregular layers of finer grit and loam. The pathways leading to Jangal pass over high terraces and ridges composed entirely of sub-recent gravels and fan deposits, shot out from the ravines of the ranges east and west of it. The wide valley of the Samilzai country, comprising several streams, as for instance of the Shéga and Kuriách ravines, is almost entirely covered by such terraced deposits of gravels, grits, and loam, which near the margin of the hills have been joined by great fans, which have brought down sub-angular fragments, whilst the gravels and conglomerates of the terraces are clearly river-transported deposits. Amongst the fragments contained in these deposits I have only found rocks evidently derived from the cretaceous and nummulitic formations, which thus seem to form the high hill masses of the Mazjogáh and adjoining peaks.

Description of Sections.

Section between Darband and Gwáda in the valley of the Khanki River.—The village of Darband lies at the foot of the southern slope of the Samána range which at this point has a direction almost due east and west, and divides the Khanki river from the southern tributaries which eventually form the Kohát Towi. The ground between the Samána range and the hills of the Miranzai country forms a valley varying from 2 to 6 miles in width, and is much broken up by smaller streams which have eroded the trough into numerous smaller drainage basins, separated by low ridges. These secondary valleys are generally fertile and cultivated, as for instance is that of Hangú and Darband. Roughly speaking, the boundary between the tertiary formations and the older rocks runs along the foot of the Samána range, which is chiefly formed by the latter, whereas the low hills along the skirt of the range and situated in the valley of the Upper Kohát Towi are all composed of lower tertiary beds. The village of Darband itself lies close to the boundary between nummulitic limestone and some massively bedded limestone which has not yielded any fossils but which I include with the nummulitic limestone; the latter is associated higher up with green shales of a bright olive colour and red sandstone beds, the dip of which is nearly exactly 20° S. E. The difference between the hard grey limestone underlying the nummulitic beds and the latter itself is also plainly shown in the surface configuration of the country.

Samána range.

The Samána range presents in most sections an irregular dip slope towards the south whilst denudation has resulted in the formation of a second range, south of the former, but composed of nummulites entirely, which, whilst showing generally a steep scarp to the north, dip also south to south-east under an angle of about 20°.

Limestone beds.

Quartz-sandstone.

The temporary road constructed by the troops of the first Miranzai Expedition when advancing from Darband to Gwáda in the Khanki valley, passes over a very fair section of the strata which underlie the nummulitic series. The ascent over the southern slope of the Samána range winds along a spur sent out by the latter; the rocks passed *en route* are more or less exposed in a dip slope, the beds of which are much cut into by ravines, and there is also a considerable amount of jointing visible, as it might be expected in rocks of this character. I passed over a great thickness of hard, massive limestone beds which underlie the lower nummulitic limestone mentioned; they are much weathered on the surface, on which traces of fossils may be detected, apparently of small bivalves and brachiopods, which, however, are not separable from the rock itself. This is alternating with flaggy beds of marly limestone, with occasional reddish patches. Towards the top of the Kótal-i-Darband (4,440′) the beds become more massive, and I found intercalated between them a considerable thickness, certainly of not less than from 400′ to 600′ of a very hard whitish grey to rusty brown quartz-sandstone in thick beds. This sandstone reminded me much of the similar sandstone which forms the great mass of the base of the Takht-i-Sulaimán range some 120 miles south-east of the Samána ridge, and I believe I am right in identifying both these formations with lower cretaceous.

Brachiopods.

The crest of the Samána range is seemingly entirely made up of beds of this division, though there are partings, and here and there considerable thicknesses of limestone, mostly light grey in colour, intercalated between the quartz-sandstone. The top of the Darband Kótal is chiefly composed of the latter, whilst I noticed beds of the grey limestone making their appearance lower down the division. The descent from the Kotal to the Khanki river valley near Saifaldarra is down a rugged ravine, on both sides of which a pretty good section of the lower cretaceous is exposed. The road leads over the upturned beds of a descending section, the strata of which dip about 20° due south. Thick beds of the quartz-sandstone are inter-stratified with occasional beds of marly limestone, and even a few beds of calcareous shales, which most of them show fossils in abundance—*brachiopods* which are rarely in condition good enough for determination.

Jurassic.

Towards the base of the section, near Saifaldarra itself (which is situated on a slipped mass and fan deposit), the limestone predominate, and in fact passes into the lowest beds exposed, a darker grey, very hard limestone with fossils, which I look upon (see list of formations, p. 83) as upper jurassic in age.

Tútiméla pass.

Section north of Hangú.—The Samána range north of Hangú presents almost identically the same section. Hangú itself is built on recent gravels and the fan deposit shot out from the ravines eroded out of the nummulitic limestone, which forms a chain of low hills skirting the Samána range along its south slope. The path which leads from Hangú to Tútiméla in the Khanki valley, passes through a gap between these nummulitic limestone hills, the beds of which dip 20° to 25° S. E. About a mile and a half north of Hangú the path leads along the side of the nummulitic section, and I noticed there the hard grey unfossiliferous limestone (4 in the

above list of formations) dipping below the marly nummulitic limestone. It forms at this point an isolated hillock, and is separated by fans and recent deposits from the Samána range itself. One ascends there a very disturbed and irregular dip slope to the Tútiméla pass. The section is very similar to the one north of Darband. At first one meets limestone with traces of fossils, and near the crest of the range itself hard grey and reddish brown quartz-sandstone. The dip of these beds is about 30° S. E., and they seem to overlie conformably limestone beds which are *in situ* lower down on the north slope of the Samána range, which is here between 4,000′ and 5,000′ high.

The Khanki valley and the range forming the north side of it.—The Khanki river has eroded a deep V-shaped trough along the axis of an anticlinal (see sect. 3, pl. 1). There are terraces formed on each side by the spreading fans which issue from the side ravines and collect at the base of scarps; the river, cutting through these fans and winding from one side to the other, has produced the more or less level accumulations of debris known amongst the frontier people as "Kuch." They are usually well cultivated, and form village sites as a rule; such terraces are situated on both sides of the valley near Gwáda, where the troops of the expedition were halted for several days. South of Gwáda the Samána range descends in a series of rough spurs, whilst the opposite side of the valley presents huge scarps towards the south, thus forming fine sections through the anticlinal. A ravine joins the Khanki valley about a mile and a half east of Gwáda, and, as it intersects the beds at a right angle, it affords a good opportunity to study the sequence of beds. It issues into the main valley not far from a village called Narai, consisting of a tower and a few huts. As mentioned above, the river Khanki has eroded through an anticlinal along its axis; the beds forming it are seen to dip from 20° to 25° S. S. W. and about 30° N. N. E.

Section of the Narai ravine.

The lowest beds of the anticlinal are exposed on both sides of the valley near Gwáda, and they are seen for several miles downstream. This horizon is formed chiefly by limestone beds belonging to the division (7) of the list given above. They are especially well seen in the steep scarp on the left side of the valley, where a thickness of about 250′ of hard, flaggy dark grey limestone, with some subordinate beds of calcareous shales and thin-bedded limestone, is exposed, their base being hidden. Fossil traces occur throughout the limestone beds, but are difficult to chisel out of the hard rock. *Brachiopods* and small *bivalves* are common, amongst which a small *ostrea* seems to fill the rock in places.

Lower limestone.

Fossils.

I have no direct fossil evidence regarding the age of this division; the lithological character, especially of the shales intercalated in the limestone, together with the fact that the series underlies the quartz-sandstone division, remind me strongly of a similar sequence in the section of the Takht-i-Sulaimán, where a cretaceous quartz-sandstone also overlies an upper jurassic (or neocomian?) series of shales and limestones. At all events the limestone division (7) can scarce be younger than lower cretaceous.

This division forms the cliff on both sides of the entrance to the ravine near Narai, and I observed there that its beds dip about 35° N. and N. N. E. Ascending the ravine, and with it also the section, I observed the same fossiliferous lime-

stone for some 200 yards higher up, scarcely, if, at all, varying in character. It is overlaid by some 30′ to 40′ of a very hard calcareous, brown sandstone with rusty spots; I found a few fossil traces, amongst which fragments of what appears to be a cephalopod (*hamites ?*). Resting on this sandstone, I found a great thickness (some 80′ to 100′) of marly limestone beds with conchoidal shales and partings of very hard marly limestone. They are mostly of light grey to lavender colour, with dark grey beds which weather brownish. They contain fossil traces, sections of shells, carbonized fragments of stems, and fragments of lignitic wood, none of which I could separate from the surrounding rock. The series dips 50° N. N. E. and is followed higher up by calcareous sandstone with a few quartz-sandstone beds of light brownish red colour; ferruginous concretions occur in the former, whilst the latter forms the greater mass of the remainder of the cliff. Close to the top of the latter, however, hard grey limestone appears again in beds of from a few inches to over two feet in thickness, generally flaggy in character. Nearly every bed seems to contain fossil traces, but I could not find determinable specimens, the surrounding rock being so much harder than the shells themselves. The dip remains still to north-north-east, and from the heights overhanging the left side of the Khanki valley, I observed that the same limestone beds form the hills immediately to the north of it. Dip rolling, but on the whole to the north.

Quartz-sandstone.

Hamites ?

Upper limestone.

The section between Darband and Saifaldarra, which forms the southern shoulder of the anticlinal, and the sequence seen in the ravine north of Narai is identical and in descending order as follows :—

5.	(*d*)	Great thickness of grey limestone with subordinate sandstone beds; fossils indistinct and hard to get out of the rock.	Upper	Cretaceous.
	(*c*)	Quartzites and quartz-sandstone in massive beds with ferruginous concretions.	Lower	
7.	(*b*)	Limestone beds alternating with great thickness of calcareous shales with ferruginous concretions; marly grey limestone with fossil shells and partings of one or two quartz-sandstone beds.		Jurassic or Neocomian ?
	(*a*)	Hard, dark grey limestone with partings of calcareous shales; many fossils, chiefly small *bivalves*.		

Sections in the Sheikhán valley.—The march of the Miranzai Expedition from Gwáda to the Sheikhán country was at first down-stream to near Shew Khéyl and thence over the sub-recent gravel and fan deposits of Jangal and Mír Askar to the narrow, but highly picturesque valley of Sheikhán. On the way there little is seen which would clear up the geological structure of these hills; the quartz-sandstone and the underlying grey shell limestone may be seen on each side of the Khank valley (of the Gosbin river) dipping more or less north and south. Near Turi the section dips more south-east than south, and thus disappears just west of Shew Khéyl below the fan deposit on which that place is built.

There is not much instruction to be gathered from the very extensive fan and gravel deposits of Jangal and Mir Askar during a long march but fine profiles of the surrounding country may be seen, and it becomes evident that a second, though crushed, anticlinal

Northern anticlinal. Sheikhán valley.

follows north of the Gwáda flexure; the Sheikhán stream having eroded its course through the beds forming this fold in much the same manner as the Gorbin river of the Khanki valley has done. But our stay at Laghardarra was too short, and the weather too unfavourable at that season of the year to do more than reconnoitre the valley. Two streams—one south, the other north—have scooped out narrow V-shaped valleys, and flowing east and east-south-east unite near Drang (Dran), where they form the Sheikhán stream, which is known further down as the Shéga stream. Numerous ravines cut into the hill ranges bounding the valley, but I had only an opportunity of ascending the two principal branches of the valley. The hills bounding the valley on both sides are made up principally of the quartz-sandstone and upper limestone of the cretaceous system, and it appears most probable to me that a line of fault runs east and west through the Sheikhán anticlinal exposing between the village Drang (Dran) and the range north of it, the lower limestone and shales underlying the quartz-sandstone already described. Such supposition seems most probable, from the fact that the upper cretaceous limestone, which forms the range on the right side of the valley, apparently dips below the lower cretaceous beds north of Drang. Not only this, but looking up the valley west of Drang, the bedding of the ranges forming the head of the valley indicates a crushed fault, probably the remains of a fold-fault. Light grey earthy limestones with fossil traces are seen in the southern branches of the head waters of the Sheikhán stream south-west of Drang. They are associated with ochreous yellowish green, to brown shales, in which I did not find any fossils. The valley which forms the northern branch of the head waters of the Sheikhán stream shows these lower fossiliferous limestones a trifle better developed. North-east of Drang this limestone with earthy shales is *in situ*, and there the former has yielded some *brachiopods*: I look upon this series of beds as either upper jurassic or neocomian, and they underlie the quartz-sandstone of the lower cretaceous, which I have already described in the Samána section.

The pass which leads from the Sheikhán valley to Torsmats was at the time of my visit so much blocked up by snow that I found the greatest difficulty in even ascending to the foot of it; the rocks which form the north side of it (left side of valley) seem to belong to the lower cretaceous sandstone, and are overlaid by grey limestones, all dipping north-west and north to north-east about 40°.

Carbonaceous shales.

About half-way between Drang and this pass La Khúgha (Atghoki of map), some beds are *in situ*, chiefly grey concretionary shales, calcareous, which contain some traces of vegetable remains and coaly patches, all dipping 45° N.: they reminded me of the plant-beds of Dobandi west of the Shutargardan in Áfghánistán, which beds are either upper trias or lower rhætic, but, in the absence of fossil evidence, I did not feel justified in separating these Sheikhán valley shales from the jurassic (?) or neocomian series, which is *in situ* in the valley.

Sequence of beds.

The succession of the lowest beds exposed near Drang seems to be in descending order:—

1. Hard limestone in thick beds with fossils; chiefly *brachiopods* and a small *ostrea*.
2. Plant-bearing shales.
3. Calcareous sandstone with calcareous shales, very concretionary.

The section is followed above by limestone and shales, which are intercalated by, and finally overlaid by, great thicknesses of sandstones of lower cretaceous type.

Section over the Istarghar range.—The only section I have seen across this range was obtained when marching with General Sir William Lockhart's force to Zéra in the Sturi Khéyl country. The visit was of too short a duration and the weather too inclement during the march to enable me to say more about it than that the sequence of the strata which form this valley of Zéra is apparently the same as observed in the more southern sections, at all events as regards the cretaceous rocks. It is apparently a sequence of (1) limestones, (2) sandstone, and, again, (3) upper cretaceous limestone, similar to the section of the range north of Gwáda in the Khanki valley, but whether or not along the southern skirts of the range some older cretaceous or jurassic rocks appear is doubtful. This series of beds dips north-east and north as far as I have observed, whilst I am quite unable to say how this section continues northwards.

The Istarghar range continues eastwards into the Afridi hills north of Kohát, which, as will be seen, is probably entirely made up of cretaceous and perhaps jurassic rocks, with a fringing belt of older tertiaries. Between this chain of hills and the main range of the Saféd Kóh is a gap in our knowledge of the structure of this mountain mass. North of the latter we know of the presence of palæozoic rocks,[1] but how the cretaceous, or at all events mesozoic, strata of the Urakzai and Afridi hills are related to the palæozoic rocks of the main range we can only conjecture. I believe it will be found that the Kharwár and Shutargardan dislocation (see Chapter I) is continued eastwards, and that it separates the mesozoic Urakzai ranges from the Saféd Kóh.

Conclusion.

Fragmentary as an account of the geology of the Urakzai hills must necessarily be, which has been compiled from notes made during an expedition conducted in January and February, I may yet claim that they clear up the following points in frontier geology:—

1. The section of the Samána range towards the south is a normal one; the lower eocene (nummulitic) beds of the Miranzai valley follow conformably on the upper cretaceous rocks of the Samána range itself.
2. The ranges which skirt the Saféd Kóh along its southern slope are chiefly made up of mesozoic beds, which range from the upper cretaceous to jurassic and *perhaps* rhætic age.
3. These strata are compressed into several flexures, which have resulted in one or two places in fold-faults along the strike of the beds and present hill ranges.
4. Though differing in detail, the sequence of the formations represented within these folds corresponds in a remarkable degree with the sequence of beds seen in the Sulaimán range, where the mesozoic strata are in descending order as follows:—

Upper cretaceous . . .	3. Limestone (coral), passing upwards into the nummulitic beds.
Lower cretaceous . . .	2. Quartz-sandstone.
Jurassic ? or neocomian . .	1. Shales, sandstones, and marls, with *ammonites*.

Leaving out details, this is also the sequence seen in the Samána range.

[1] Quart. Jour. Geol. Soc., 1850, p. 45; also Manual of the Geology of India, p. 500.

III.—The Geology of the Khaibar Hills.

Being the eastern termination of the Siáh Kóh system.

The Khaibar hills form the mountain mass which divides the valleys of Jalálábád and Peshäwar, bounded north by the Kábul river and south by the main range of the Sáfed Kóh. Structurally considered, they are part of the northern skirting ranges of the Saféd Kóh system and as such are but the eastern terminations of the ranges which lie between the Saféd Kóh and the Siáh Kóh, and probably include a great part of the eastern spurs of the latter. The strike of the rocks composing this minor system averages from east to west, which is also the direction of the principal drainage, more or less parallel to the Kábul river valley.

Drainage.

The principal drainage consists of the mountain streams which run into the Kábul river, all of which flow in transverse valleys; whilst the Khaibar and Bazár valley rivers run more or less in longitudinal troughs.

Main axis.

The main axis of the Saféd Kóh continues with an almost due west and east direction into the Pesháwar valley a few miles south of the 34° Lat. and forms the high, partly snow-covered range dividing the Bazár valley from the Torbéla and Bárá rivers.

South of this main axis run the southern skirting ranges, of which the Urakzai hills described in Chapter II form part; whilst north of it the Khaibar ranges follow in close succession till the Kábul river valley is reached.

Fossils of Jamrúd.

Geologically, only the southern portion of the Urakzai hills and the Khaibar ranges are known; whilst the structure of the eastern part of the main axis of the Saféd Kóh can only be guessed at. The only data we have to go upon are some fossils which are said to have been found in boulders which were brought down by the Khaibar river near Jamrúd. They have given rise to a great deal of discussion, were spoken of by Colonel Godwin-Austen[1] (as being lower silurian); but, on the other hand, other writers believe these fossils to be of carboniferous age).[2]

Northern slope of main axis palæozoic.

They have most likely been derived from the high range which divides the Khaibar valley (with Lundi Kótal) from the Bazár valley: the rocks composing this range are continued east into the hills about Ali Masjíd, which I believe to be carboniferous. They dip down into a synclinal, which, roughly speaking, coincides with the Bazár valley. Thus, the northern slope of the main range of the Saféd Kóh south of the Khaibar hills will most probably be found to be formed by carboniferous, or at all events of lower palæozoic strata.

Section from north to south.

A section from south to north between the Saféd Kóh and the Kabul river valley (see fig. 3, pl. 1), demonstrates the existence of a series of reversed flexures into which the strata of the Khaibar hills have been laid. The compression which the section has suffered has resulted in a considerable amount of local crushing and faulting; the line of disturbance which nearly coincides with the Lohi Shilmán

[1] Quart. Jour. Geol. Soc., II, p. 260; VII, pp. 38 to 46.
[2] See "Manual," p. 500.

valley is also here accompanied by intrusions of igneous rocks of basic character, which are strongly developed north of the Lohi Shilmán valley and which appear in the strike of the igneous rocks of the Jalálábád valley. This line of disturbance will, I believe, be found to belong to the same system of faults to which I have alluded in my chapter on the Siáh Kóh and the rocks east of it.

List of formations.

In the Khaibar hills area I found the following rock systems represented :—

(*e*) Complex of shales and earthy beds	Trias ?
(*d*) Limestone and alum shales series	Carboniferous.
(*c*) Metamorphic strata, with graphitic layers	Carboniferous.
(*b*) Phyllites and schists	Older palæozoic.
(*a*) Gneissic series	Older palæozoic.

Gneissic series and schists.

The oldest rocks met with in the Khaibar hills occupy two wide belts, namely the line of the Tor Sapper (north of Lundi Kótal) and the hills east of it and the hills north of the Lohi Shilmán valley to the Kábul river. These belts are formed by two reversed anticlinals, which are deeply eroded and thus have their older beds exposed. A fold-fault has further brought these rocks in superposition over the palæozoic limestone (*d*)[1] near the Lohi Shilmán valley.

The series is formed by grey thick-bedded gneiss, which is overlaid by mica and talcose schists, with which grey phyllites are associated; there is no sharp boundary between these schists and the gneissic series lower down, nor between the former and the metamorphic strata above. A very good section is obtained through the whole group west of the Tor Sapper peaks; the path which leads from Lundi Kótal past Ashúkhéyl into the Lohi Shilmán valley traverses in succession the schistose series (*b*) and the metamorphic strata with graphitic layers (*c*) north of the Tor Sapper; and there is certainly no well-defined boundary between the divisions of the system of strata.

Graphitic layers in Tor Sapper beds; no coal-seams.

The Tor Sapper is formed by metamorphic shales, micaceous and talcose, with quartzitic beds intercalated: numerous graphitic layers are found interstratified between the beds, and they have given rise to the belief in the existence of coal measures within the Khaibar hills, but it is scarcely needless to say that there is not a single coal-seam to be found within the area.

The dip and strike vary a good deal, though the former averages north and north-west. Immediately south of the Tor Sapper the section is interrupted by the recent and sub-recent deposits of Lundi Kótal, which consist of grits, clays, and sandstone beds, and which horizontally and unconformably overlie the older rocks.

East and south-east of the Tor Sapper.

To continue the section it is necessary to examine the hills east and south-east of the Tor Sapper: I found that the area between the latter and the Tartara hills is occupied by a reversed anticlinal, dipping due north-west. These two ranges are formed chiefly by the metamorphic series with graphitic layers, flanked on both sides (north slope of the Tor Sapper, Rotas peak and hills about Ali Masjíd) by dark limestones. The oldest rocks of the section, namely the gneissic and schistose series, are in

[1] 2 in fig. 3.

strong force in the north-eastern portion of the anticlinal, where they form the greater mass of the Mohmand hills of the eastern end of the Kábul river gorge.

North slope of the Tor Sapper.

The north slope of the Tor Sapper, as already said, is formed by limestones partially altered into marble near contact with granites; these limestone beds are conformable with the graphitic schists below, and share with the latter in all the minor folding and disturbances. They dip below the recent deposits of the Lohi Shilmán valley, but re-appear north of Umarai again, on the left side of the valley. The line of the Lohi Shilmán valley marks the direction of a dislocation in the form of a fold fault, or system of such. Hornblendic granite in veins near Sarobi and trap intrusions along the northern (left) side of the valley obscure the section a good deal, but as all the hills north of this line are formed by schists and a gneissic series, the beds of which dip north-west, it seems that they must have been pushed over the relatively younger limestone division, which they now apparently overlie. This structure might possibly be explained as a reversed synclinal, of which the limestone forms the centre; but there is no direct evidence to warrant this assumption; whilst, on the other hand, the great local disturbance and crushing near Umarai, and the appearance of igneous intrusions along a line which is in the general strike of the Jalálábád disturbance, speak for a continuance also in this area of the fold-fault (?) on the south flank of the Siáh Kóh (see fig. 3, pl. 1).

Kam Shilmán.

The area immediately east of the Tor Sapper has undergone a good deal of minor disturbance, folding and crushing, but, nevertheless, it is not difficult to understand the section when looked upon as part of the reversed anticlinal of the Tor Sapper.

The valley of Kam Shilmán, north-east of Lundi Kótal, runs at first almost due north-east, more or less in the direction of the strike of the strata, then turns nearly east and joins the Kábul river valley. From south to north it forms a normally ascending section, it being the northern half of the anticlinal. The rock which forms the low Kótal, which leads from the Kam Shilmán valley into the Lundi Kótal basin; is formed of metamorphic schists, among which a micaceous slate and talcose phyllites are most prominent. They are traversed across the bedding by white quartz veins, and numerous lenticular masses of quartz are intercalated between the schists. It was thought that they might prove auriferous, and I was deputed to examine this locality, but I have not discovered a single trace of gold in either schists or quartz veins.

No gold.

Further to north-west, along the south-eastern slopes of the Tor Sapper, the metamorphic graphitic series (*c*) overlies the schists conformably; and in fact the latter gradually pass into the former. They strike more or less along the left side of the valley to near where the road to Shahidmaina branches off to the east, where they are overlaid by the dark limestone (*d*, carboniferous ?). The graphitic series forms a regular sequence of semi-metamorphic schists, which are closely connected with the schists below, but which, near the middle of the section, may be described as a great thickness of calcareous phyllites, with occasional micaceous slates intercalated. Lavender-coloured clay shales with beds of bituminous alum shales form several distinct horizons, which contain numerous layers of graphite and graphitic shales.

Some springs below Sheikh Báber's village (on the right side of the valley trickle out along a joint in this division (*c*), and the section is there made up of

calcareous shales, alternating with soft clay-shales and occasional partings of ferruginous concretionary layers: with it occur considerable thicknesses of dark, bituminous alum shales with graphitic layers and ferruginous partings. The alum shales contain strings and crystals of iron-pyrites which decompose, and then slightly raise the temperature of the trickling springs which rise along joint planes of this formation. The ferruginous film which forms on the surface of the stagnant pools of the springs have given rise to the reports of the existence of petroleum springs in Kam Shilmán.

Supposed petroleum springs.

There is of course not a trace of petroleum or cf any other hydro-carbons found in this section.

Higher up in the section (well seen on the hill slope on the right side of the valley) some thin beds of dark limestone occur intercalated within the shales; and the limestone beds increasing in number, gradually replace the shales entirely, till the section becomes a sequence of dark, hard, and splintery limestone beds, traversed by calcspar veins and easily recognised as the limestone (*d*) of the north slope of the Tor Sapper and of the Tartara peak further to the south.

This same limestone is in great force near where the Shahidmaina road branches off across the mountain range, but immediately north of this point this division is suddenly brought into contact with the mica schist and gneissic series, which are pushed over disturbed beds of the limestone and on the left side of the valley over the graphitic schists which underlie the limestone (*d*). The dip of the graphitic series (*c*) near the so-called petroleum springs of Kam Shilmán is from 40° to 50° N. W., and the super-imposed limestone continues with almost the same dip till the whole is brought in faulted contact with the gneissic beds of the Kábul river gorge.

I may here add that the thin-bedded limestone at the base of the limestone division (*d*) in the Kam Silmán valley contains garnets which are also found in the shaly partings between the limestone beds.

The section from the Tor Sapper to south-east traverses the strata almost at right angles to their strike, and may be rendered diagrammatically as shown in fig. 3. The south-east scarp of the Tor Sapper is formed by the highly altered graphitic series (*c*), which there shows a thickness of about 3,000′ to 4,000′ at the most; these, as I have already shown, rest conformably on a great thickness of grey phyllites. When I say phyllites, I mean that the most prominent of the strata composing this division is made up of phyllites with intercalated talcose schists (garnetiferous) and crystalline limestone beds. But these beds pass gradually into micaceous schists of unknown thickness, which again (limestone and shale beds are even seen as low down) pass into the gneissic series of the Mohmand hills. The mountainous tract south of the Tartara route, and which includes some high peaks (Tartara 6,775′, Rotas 5,460′), minor folds not considered, forms the southern shoulder of the reversed anticlinal (see fig. 3); and the south-eastern extension of this hill tract is again formed by the dark, splintery limestone (*d*), much jointed, faulted, and with many minor folds, which repeat the section several times.

South-east of Tor Sapper.

This limestone (*d*) is perhaps best seen in the high cliffs about Ali Masjid on both sides of the Khaibar river. The prevailing rock of this division is a hard splintery dark grey limestone traversed in all directions by calcspar veins and joints. There are

Limestone (*d*) carboniferous?

partings of calcareous shales and splintery alum shales, but the general characteristics are those of a limestone formation. It would be hazardous to compare this limestone formation with any other similar formation far distant, but I was struck with the great lithological resemblance between it and the carboniferous limestone both of the Himálayas and the Hindu Kush: certain it is that palæozoic strata occur, probably carboniferous, within these hill-ranges; and the inference is that this limestone formation may be the original source of the fossils found near Jamrúd.

Minor folds, always with the same reversed character shown in the structure of this mountain mass, may be seen well exposed near Ali Masjíd, where in an anticlinal, leaning over to the south-east, the graphitic schists (*c*) are found inclosed in the dark limestone (*d*). The section is very instructive indeed, and explains the structure of the Rotas hill east of Ali Masjíd perfectly.

Shales.

The limestone (*d*) of the southern shoulder of this anticlinal dips (in reversed order) below a series of shales (*e*), which are in great force from $1\frac{1}{2}$ mile south-east of Ali Masjíd to the eastern mouth of the Khaibar (3 miles west of Jamrúd).

This series of strata consists chiefly of earthy alum shales and sandstones with subordinate limestone beds and some strata which are principally made up of trappean material. The prevailing colour is brownish green with dark bands, and the rapid disintegration of the shaly portion favours the formation of low undulating hills, which strongly contrast with the precipitous limestone cliffs which form the ranges around.

This shaly formation (*c*) cannot but be younger than the limestone (*d*): the latter is, as shown above, probably of carboniferous age, and structurally represents the *crinoid* limestone of the Siáh Kóh, and it therefore follows that the shales (*e*) overlying this limestone must be either upper carboniferous or even younger, and may possibly be found to be of triassic age.

The division (*e*) is probably developed in great thickness in the Khaibar; it is evidently much disturbed, and an estimate of the extent of the formation could not be made in the section exposed near the eastern part of the pass. But I think it is quite clear that these shales are inclosed in a great synclinal of limestone, probably of carboniferous age, which synclinal will be found to coincide more or less with the strike of the Bazár valley.

IV.—Section between the Peshâwar Valley and the Ungo Pass; the Petroleum springs of Pannóba.

In the previous pages I have shown that the Saféd Kóh mountains are skirted along their southern slope by a series of ranges of lesser elevation which pursue a course more or less parallel to the main axis of the system. The latter comes to a termination south of Jamrúd and some ten miles west of Peshâwar. The southern ranges I believe to be separated from the main ranges by a long line of fault. Of them I only know the south-western extremity ending in Afghánistán and part of the Urakzai hills (see Chapter II), but the latter continue eastwards and form the bare hills of our Kohát frontier, the Afridi hills east of it; and they pass, still a well-defined range, east north-east into British territory, where we know them as the Cherát hills, which may be considered to end at Attock on the Indus.

These hills also are formed, not by one chain alone, but by a series of ranges more or less parallel to each other. The parallelism is continued into the lower ranges which skirt the former along their southern slope, in the same manner as the Miranzai hills run more or less parallel with the higher Samána and ranges further north.

A section across this series of ranges is described by Professor W. Waagen in Palæontologia Indica, Vol. IV, pt. 1, p. 14 ff., and partly by Wynne, "Records," Vol. X, p. 128, and Vol. XII, p 102. The section which I examined *en route* from Pesháwar to the Pannóba oil-springs led me over the Cherát and Mir Kalán passes; and south-east of the latter, over the Nilábgash Kótal, which crosses the series of lower ranges skirting the Cherát and Afridi hills along their southern slope.

This belt of parallel ranges is made up of highly contorted beds, the lowest of which are certainly not younger than mesozoic, and which go up into upper tertiaries. Part of the belt is made up of the so-called "Attock" slates of supposed palæozoic age. I have only seen types of the latter west of Cherát, but at all events as regards these I am exceedingly sceptical, and would include them rather amongst the tertiary strata, as will be explained hereafter.

Contact between the tertiary system and the cretaceous beds.

I have shown that the Urakzai hills (see Chapter II) are skirted along their southern slopes by tertiary beds (Eocene) which rest conformably on the upper cretaceous strata of the Samána range; and here at all events the contact is quite normal, as may be seen at Hangú and Darband on the Miranzai frontier. Further east occur nummulitic beds, but I am not quite inclined to endorse Mr. Wynne's observation, which would prove (Rec. XII p. 100 ff.) that the line of juncture between the older limestones which chiefly form the "Afridi" hills and the nummulitic beds is a discordant one. There is a good deal of local disturbance certainly, and minor faults must be numerous, but on several important sections I have found the junction perfectly normal, and the nummulitic beds reposing conformably on the cretaceous limestone below. Such is the case along the Samána range frontier and Kohát itself; whilst north of the Nilábgash the cretaceous limestone dips certainly quite conformably below the nummulitic beds.

Kohát pass.

It is possible that there is some disturbance in the neighbourhood of the Ublán pass, which I have not visited. But viewed from a distance of about a mile, it appears as if the limestone strata of this pass and the nummulitic beds south of it (in British territory) were dipping in quite opposite directions. This disturbance is possibly continued some few miles eastwards, for between Kohát and the entrance to the Kohát pass there is evidence of much disturbance in the nummulitic beds which are *in situ* there. Near Fort Garnett north of Kohát, these beds are seen to dip south (60°) away from the pass limestone, whilst not far east from this spot, they dip against the latter. But there is no direct contact *in situ*, and deductions are risky in such a highly disturbed area.

The Kohát pass traverses the entire range of hills, which are a continuation eastwards of the Urakzai ranges.

Near the top of the pass, close to the Militia post, the beds dip 25° N. E.; they are ochreous shales, of reddish and yellow colour, very friable, interstratified with coarse grits and sandstone, which are overlaid by thick-bedded, dark grey limestone. The shales reminded me much of the earthy shales which are *in situ* in the

Sheikhán valley (see Chapter II), which may be of jurassic age. The limestone of the Kohát pass is probably cretaceous, or at any rate mesozoic.

The structure of the section is extremely disturbed; the hill side which forms the eastern side to the pass shows this plainly. The limestone beds of this cliff are so much twisted that it would be impossible to map individual divisions forming the section. The crest of the range is made up of nearly vertical strata, whilst a little way lower down they dip south. A similarly contorted section is seen in Cherát, twenty miles north-east. In marching through the pass one traverses severa anticlinal folds almost entirely made up of hard dark, grey limestone beds which I believe belong to the cretaceous system, and are in fact the limestones which I met in such great force in the Urakzai hills.

A closer inspection of the structure of these ranges is not possible in the Kohát pass, which, though open to travellers, traverses country belonging to independent Afridi clans. Much more favourable is the route across the Cherát and Mír Kalán (not Mir Kulan) passes.

Cherát and Mír Kalán passes.

Both Wynne, and more recently Professor Waagen, have given descriptions of the section over this range. The section may be divided into two parts: first, the northern one, which traverses the eastern continuation of the Afridi hills near Cherát between Jalozái in the Peshávar valley to Nizámpúr, into a wide trough filled with recent tertiaries which divides the main Afridi hills from the southern skirting ranges (see above), of which the Nilábgash is the highest point.

Then, secondly, the section over the latter ranges, *viá* the Nilábgash and Ungo passes, into the low country of Churláki and Kushalgarh formed by tertiary beds.

The Cherát section.

The Peshávar valley is filled by wide spreading recent and sub-recent deposits, which may be seen in section in the deeply eroded river courses which drain from the Afridi and Cherát range northwards. Marching due south from Jalozai (about sixteen miles south-east of Peshávar), I ascended the gentle slope of a fan which spreads from the foot of the hills into the Peshávar plain. About half a mile north-west of Dág the road, enters a belt of low hills, composed of much crushed strata with a north-east to south-west strike and a dip which varies a good deal, with a general tendency toward the north-west however. The belt formed by these strata is about two to three miles wide. The prevailing character of this belt is that of a sequence of shaly beds, with both sandstone and limestone intercalated with the former. My traverse was too rapid to have enabled me to construct an accurate section, but, as far as I could judge, I passed from Jalozái to the bungalow of Mír Kalán[1] over a normally descending section, which in outline is as follows :—

(*1*) Near Dág, grey and greenish grey marly shales, breaking into small splintery fragments; with it are beds of ferruginous sandstones and concretionary marly beds. Sandstone passing into shales and subordinate beds of grey limestone are frequent, the whole series dipping north-west under a very varying angle, which, however, is mostly high.

[1] See, fig. 4, pl. 2; also Pal. Ind., IV, p. 13.

(*h*) About one mile east of Dág I found *nummulites* in a thick bed of grey earthy limestone which conformably underlies the shale series, which I also believe to belong to the Eocene system. This limestone bed, associated with some shaly layers, rests conformably on a sequence of considerable thickness chiefly made up of reddish sandstone, red shales, and grit beds, with white and grey limestone intercalated. Some of the reddish beds are already seen in the hills two miles east of Dág, but they are still subordinate to the light coloured shales and sandstones of the upper nummulitic division.

Upper eocene.

Murree beds.

(*g*) About a mile north of Supri (or Chapri) the road enters the belt of the red grits and limestone beds of very distinct Murree bed character. They are a sequence of red clays, grits, and light-coloured limestone, the latter containing *nummulites.*

(*f*) The ridge which forms the watershed at Cherát is formed of the latter hard grey limestones which occupy the lower portions of this division. They are highly contorted beds, sometimes raised vertically, bent into narrow folds, but with an average inclination towards the north-west. The rock has yielded no distinguishable fossils, although full of organic remains, which are visible on the weathered surfaces. Small bivalves (*ostrea*) seem very common, *corals* and *foraminifera*, but not one form which could have been determined. The series is, however, easily recognised as the nummulitic division of the tertiary system.

Lower eocene.

These lower eocene limestones are seen in the station of Cherát itself, and they form the rugged cliffs east of it, but it is possible that :—

(*e*) The limestone which forms the highest point of Cherát (4,542′), and which dips very steep below this lower eocene, may already belong to the older (cretaceous ?) limestone, which is seen further south-east.

Upper cretaceous.

The road leading from Cherát to Mír Kalán village passes for about two and a half miles due east, almost entirely along the boundary between the lower nummulitic limestone (with red beds) and the grey limestone of Cherát. The latter is seen to underlie (dipping 70° N. W.) the lower eocene division close to the dákh bungalow of Mír Kalán, rather more than a mile north of the village of that name.

Below this limestone the road passes over a great deal of limestone breccia, but where the rock *in situ* is observable, the bedding is clearly with north-westerly dip. The limestone has yielded no fossils, but differs from the nummulitic beds, and I believe may safely be classed as cretaceous, which forms the greater mass of the range further west. The section below this limestone is curious.

(*d*) Overlaid conformably by the limestone (*e*), I found much plicated beds of limestone and calcareous shales, which again rest on :—

(*c*) Hard light-coloured quartz-sandstone in thick beds, which contain numerous decomposed crystals of garnets, and may be called at places a garnetiferous quartzite.

Lower cretaceous ?

(*b*) The quartzite rests conformably on grey calcareous shales which, in cliffs, have a very characteristic banded appearance, and lithologically, reminded me strongly of the indurated shales of the lower Simla series. As in the latter, some horizons of dark calcareous shales are intercalated, which are strongly carbonaceous with ferruginous layers, which decomposing yellow give the whole a brownish tint. The same shales are noticeable in Cherát in the western continuation of the strike. They dip 50° N.

Jurassic?

Spiti shales?

(*a*) Lower down the road these shales are seen to overlie grey foraminiferous limestones with partings of highly altered micaceous shales. The limestone is in thick beds, and on its weathered surfaces organic remains may be seen in section, and are pretty numerous, though limited to certain layers. The fossils seen are sections of *corals, foraminifera*, and small *bivalves* (*ostrea?*), but I could not get anything out in sufficiently good condition for determination, as the limestone is highly indurated.

Lower down this section, near the village of Mír Kalán, the beds are covered up unconformably by the recent fan deposits and sandstones of the upper tertiary series, which is in great force in this valley.

Section probably an anticlinal.

But though the section is entirely descending as far as Mír Kalán,—an unbroken sequence,—yet I think it is highly probable that the range from Dág to Mír Kalán forms in reality only the northern half of an anticlinal fold: looking westwards one may observe what appears to be the red nummulitic series (Murree beds) with limestone lower down, all dipping south and seemingly forming an arch, of which Mír Kalán may possibly form the centre.

Mír Kalán beds older than eocene.

However this may be, it is certain that the Mír Kalán beds are older than eocene: without determinable fossils it is impossible to say how far the section may descend, but I think until further evidence is forthcoming I may be allowed to correlate the limestone underlying the Murree division of the nummulitics as upper cretaceous; whilst the quartz-sandstone and shales could conveniently be compared with the quartz-sandstone and limestone of the lower cretaceous division of the Samána range, which would make the fossiliferous limestone with micaceous shales, probably contemporaneous with the jurassic (?) beds of the Khanki valley near Gwáda (see Chapter II).

Some of the beds of this division, *i.e.*, dark shales with ferruginous partings and carbonaceous horizons, recall in some measure also the Spiti shales, though differing from the latter. I have met with shales of similar character at the base of the Takht-i-Sulaimán cretaceous, and also underlying the neocomian in Turkistán, where they yielded some jurassic fossils.

Attock slates.

It is said[1] that the Attock slates form part of the Cherát hills and are lost in the Peshàwar plain near Jalozái: from the above section it will be seen that none of the divisions as seen between Jalozái

[1] Manual, p. 500.

[2] Pal. Ind. IV, p. 24. See section, p. 13.

and Mír Kalán can justly be looked upon as anything so old as the Attock slates are supposed to be.

Neither could I discover anywhere in this section such an important dislocation as is assumed by Dr. Waagen (Pal. Ind., IV, p. 24 and section, p. 13). The hill-sides are practically quite bare of all vegetation which might interfere with a good geological view of their structure, and the strata, though contorted and locally much crushed, form an unbroken sequence.

If the greenish grey sandstones and shales of Dág would turn out palæozoic beyond doubt, then the only probable explanation of their position would be that they have been pushed over the nummulitic beds by a gigantic dip-fold, which has preserved the appearance of perfect conformity between the Dág shales and the nummulitic beds below. As it is, I failed to observe any trace of a fault in this particular section, such as Dr. Waagen indicates in his section, p. 13 and on p. 24 and as I have no other evidence as to the age of the shales, I must for the present look upon them as tertiary.

Further, I believe that, if there are any members of the palæozoic group in the eastern continuation of the Saféd Kóh system, they certainly do not form part of the Cherát and Mir Kalán section.

The Nilábgash section.

Between the range, of which the Cherát pass forms part, and the lower skirting ranges which may be crossed by the Nilábgash Kótal, intervenes the valley of the Ucha Khora stream and its drainage, which joins the Indus south-east of Nizámpúr; which valley is filled with recent and post-tertiary deposits, sandstones, loam, and detritus from the present hill ranges in the form of enormous fans. Within the lower part of the valley there is no indication of any dislocation between the two hill ranges which enclose the valley: Dr. Waagen believes that such exists (see p. 24), and this is quite possible, but at the same time it would be necessary to examine the valley higher up (nearer the Jalála) before a decided opinion can be pronounced. The season was already too far advanced to continue my survey this spring, and I hoped that I might follow up my observations this cold weather, but, having had to take up work in Burma instead, I venture to publish these notes, imperfect though they must necessarily be.

The section[1] between this valley of the Ucha Khora and Churláki (south of Pannóba) passes mostly over rocks of the tertiary system, although mesozoic beds are not absent in the northern portion of it. Here, again, gaps occur in the section between Sandlai (Sundully in Dr. Waagen's work) and the Ungo pass north of Churláki, gaps formed by more or less level tracts, covered by recent deposits out of which protrude highly contorted beds of the upper eocene division of the tertiary system. It would have been impossible to unravel the geological structure of this area on the line of march between Sandlai and the Ungo pass with so many gaps formed by recent deposits, but fortunately Dr. Waagen followed the section exposed by the Indus river from Shadipúr, and I am glad to avail myself of his explanation of the structure of these beds; but at the same time I believe that a much clearer section will be found further westwards, namely from the village of Pannóba due north-west, which section would be entirely within bare hills closely knitted together, and which section I hope to study before very long.

[1] See fig. 5, pl. 2.

My observations in the section from Nizámpúr to Sandlai differ slightly from that given on p. 13 of the Palæontologia Indica.

Sub-recent deposits of Nizámpúr.

Near the dákh bangalow at Nizámpúr, I found horizontally-bedded coarse sandstone with sandy shales and beds of sand, which formations are part of the older Indus deposits I believe. Springs of slightly warm and brackish water rise north of the dákh bungalow, and eroding the soft sandstones and shales have formed a tortuous gorge with numerous pot-holes. Over part of these sub-recent deposits of the valley stretch now enormous fans of hill-detritus, through which deep ravines have been cut by rain-torrents.

Limestone; jurassic?

The road from Nizámpúr ascends one of these fans in a south-westerly direction, about two and a half miles south-west of the dákh bungalow the road crosses a small ridge (near police tower), and I found this ridge to be formed by hard grey concretionary limestone, dipping south-east. But the bedding is much disturbed, which disturbance may be a local one only; at all events I found the limestone beds jointed in all directions, and here and there they have been converted into a kind of breccia, as is so often the case in limestone areas. The surface water percolating through the joints gradually dissolves the limestone, and undermining the beds, the latter sink in, and the interstices between the widened joints get eventually filled in by calcareous sinter till the rock presents locally the appearance of a limestone breccia.

Fossils.

Immediately south of this police post I observed the limestone beds dipping 75° almost due south. The limestone is a light grey very hard variety, thick-bedded, containing strings of chert nodules and showing on weathered surfaces numerous *brachiopods*, which are extremely difficult to separate from the rock. South of the police post the road descends into a small valley, into which this limestone dips. About a quarter of a mile south of

Quartz-sandstone.

the post, the limestone is overlaid by thick beds of a hard whitish grey quartzite or rather quartz-sandstone. This is the prevailing rock of this division, but the limestone passes gradually into the quartz-sandstone through thin beds of siliceous limestone, which are associated with earthy brownish yellow shales with which they alternate. Then follow thick beds of quartz-sandstone which becomes a series of flaggy strata of this rock, in beds of 1″ to 4 or 5″. The section is tremendously contorted, but very clearly exposed by the deep cutting of the road, and this part of the diagrammatic section (fig. 5) is taken from an actual profile. The quartz-sandstone in the lower calcareous beds contains numerous fossils which seem to be accumulated in a few layers

Fossils.

only; they are all brachiopods, amongst which a smooth *terebratula* is the commonest form.

Further south, about a mile from the police post, the road ascends the hill-range again, and there the quartz sandstone is again overlaid conformably by limestone beds. The bedding is much disturbed, and there are several crushed folds and much of jointing is observable. The road crosses the strike, which is nearly east and west.

Near Ingri village, some of the sub-recent sandstone with grits is *in situ* in horizontal beds, identical no doubt with the formation near Nizámpúr; but as they occupy the base of the valley only, they do not obscure the section in any way.

The structure of the hills is exceedingly instructive at this point of the section

Ingri flexure.

The hillside east of Ingri exhibits a natural profile of a reversed flexure leaning over to the south, followed by a low anticlinal, which in the valley of the Ingri stream rapidly dips south and conformably below the beds which are *in situ* on the right side of the valley. These folds of Ingri are made up of massive, dark grey limestones with traces of *brachiopods*, and belong to the limestone which overlies the quartz-sandstone a little over a mile north of this point.

The beds on the right side of the Ingri stream are nummulitic, and I may therefore consider the section just traversed as older and most probably of cretaceous age. It is not impossible that part of the limestone below the quartz-sandstone belongs to the upper jurassic system: it is very similar in lithological character and stratigraphical position to the brachiopod limestone near Gwáda (see Chapter II). The overlying quartz-sandstone is certainly of lower cretaceous age, and is our old acquaintance the Samána range quartz-sandstone; whilst the upper lime-stone is possibly upper cretaceous, and probably of the same horizon as the lime-stone with *hippurites* of the south slope of the Samána range.

The series of beds which overlie the upper cretaceous limestone of Ingri consist

Eocene, nummulitic limestone.

chiefly of grey limestones with earthy yellowish grey limestone beds and calcareous marly shales; some reddish beds near the base are seen to be interstratified. The limestone is highly fossiliferous, and seems filled with minute organisms, chiefly shell fragments, and *foraminifera* with some few distinct *nummulites*.

This is the nummulitic limestone of the Nilábgash, which, roughly speaking, forms a belt some two miles wide. The beds are somewhat disturbed, and there are several folds of the limestone; the Nilábgash itself certainly forming a synclinal which has been correctly rendered in Waagen's section. The descent from the pass to Sandlai (Sandully) is steep, the nummulitic limestone division forming a steep scarp towards the south in some parts. At the same time, the junction between this division and the next following (Murree beds) is not clearly a faulted one. In a highly folded area, local faults must always be found, where rocks of quite differing lithological character are squeezed into folds. The limestone of the Nilábgash is much contorted north-west of the village of Sandlai, and, north of it, dips apparently conformably below the red Murree beds south of it; whereas in the narrow valley west of Sandlai (near the Ziárat Fateh Gúl Bábá), the nummulitic beds which form the scarp on the left side of the valley dip north-west, whilst the deep red Murree beds, which are *in situ* on the right side of the ravine, are much contorted, but with a general dip towards the south.

It may signify a dislocation on a much grander scale than is visible at Sandlai, but so far I only see evidence of such local disturbance as is generally inseparable from a junction between rigid limestone beds and more friable grits and sandstones within a highly compressed and folded area.

The section between the Pallosi[1] pass and Sandlai is certainly an ascending one; though a good deal contorted, it is plainly a normal sequence of mesozoic beds, overlaid conformably by the nummulitic strata of the Nilábgash. I am unable

[1] The name Pallosi pass does not occur on the 1 inch = 1 mile maps of the district.

to accept therefore the rendering of this part of the section as shown in Palæontologia Indica, IV, p. 13.

Section from Sandlai to the Ungo pass.

From Sandlai the road leads to Churláki in an almost due south direction, and traverses on the way a country which in South Africa would be termed a "flat;" mostly level stretches of country cut about by ravines, only a few of which have running water, and out of which more or less level expanse rise a series of parallel ridges, mostly isolated or connected with the higher ground west of it by slightly rising ground. The country is very bare, and the covering of sub-recent detrital deposits very thin, and therefore there is more of the geological structure of the area exposed than would be the case in more fertile plains. Nevertheless, the rocks which form the section between the southern foot of the Nilábgash Kótal (near Sandlai) and the Ungo pass, are evidently so much contorted and crushed that it would be very hazardous either to form an estimate of the thickness of these beds or of the details of the many folds which form this belt. A better section will probably be found further westwards, where the anticlinals have not been abraded quite to the level of these "flats." I have not been able to do so yet, but Dr. Waagen, who has studied the sequence of the rocks which lie south of Sandlai, divides them into the Murree, the purple, and the grey sandstone series, respectively representing the Upper Subáthú, Dágshái, and Kasáuli divisions of the tertiary system. There are several folds of these rocks seen along the route, and, as far as may be observed, in the few good exposures one comes across, these folds are often highly compressed, reversed, and have a tendency to a southerly dip. About three miles south of Lakhotalao the road enters again a belt of hilly country entirely made up of eocene beds.

Ungo pass.

The Ungo pass (this name does not appear on the map) crosses this belt of low ranges at a right angle to their strike, and thus exposes a good section of them. The beds which form the most northern of the ridges of this belt are coarse sandstones and grits of reddish purple colour with thin beds of concretionary shales dividing the sandstone beds. The latter dip 45° N., forming long narrow ridges. I believe these beds are part of the middle eocene division, the so-called purple series (Waagen). They rest conformably on a considerable thickness of the red (Murree) series of the eocene: red sandstone, limestone (earthy), and sandstone with shales follow in succession, all conformable to each other, and dipping steadily to north. I have found no fossils in this unpromising series of beds, but as to their identity with the Murree series there can be no manner of doubt. Mr. Wynne has described this particular section (Records, XII, p. 102).

Petroleum springs of Pannóba.

The special object in making this traverse was to reach the valley of Pannóba, about two miles west of the Ungo pass, where petroleum was known to ooze out in small quantities, and regarding which fresh evidence was required. This petroleum occurrence has been known to exist, and, in fact, has already been reported on by Mr. Benjamin Smith Lyman, in "General Report on the Punjab Oil Lands, Lahore, 1870;" on page 34 ff. occurs his "Report on the Pannóba Oil Lands."

I had this report with me when examining the Pannóba valley and the surrounding country last field season; and as the hillsides are nearly absolutely bare of vegetation, there is no difficulty at all in unravelling their geological structure, and I can,

after a careful examination, say that Mr. Lyman's geology is absolutely wrong; nor is the topographical map attached to his report any more accurate. To criticise his geological section in detail would be unnecessary. It will suffice to point out that: first, there are none of the anticlinals shown in the deep gorge of the Pannóba stream, which he draws in his section. The sequence on the south-east side of the fault is a steadily descending one till the beds are covered up by the fans which spread into the Churláki plain beyond. Secondly, there is not a trace of an "oil-line" shown by any indication whatsoever. The oil oozes out from one of the innumerable joints adjoining the fault, and the so-called oil-bed is unknown; neither do the folds exist as drawn in his section, which is pure invention.

Pannóba tertiaries.

The rocks *in situ* at Pannóba and the neighbouring valleys [1] all belong to the tertiary system.

The youngest rocks which are seen are the Murree beds and immediately overlying sandstones; they proved unfossiliferous, but they are easy of recognition, and have already been described by both Wynne and Waagen. They occur on both sides of the hill-ranges within which the villages of Pannóba and Trakhobái are situated; they are faulted against the older eocene beds along the south-eastern flank of the range whilst they rest conformably and in perfectly normal order on the nummulitic limestone along the north-western slope of the chain of hills of which the Narai Sir is a conspicuous point.

Formations represented.

The lower eocene division is well represented, and the complete section would thus be in descending order:—

Murree series of Wynne.		g. Sandstones and grits with subordinate limestone beds; prevailing colour of sandstones red.	Upper	
	Subáthu?	f_4. Limestone beds of the Narai Sir range; contains *nummulites*.		
		f_3. Purplish red sandstone and shales of the Narai Sir range; thickness from 600′ to 700′.	Middle.	Eocene.
		f_2. Limestone with reddish patches, earthy; contains *nummulites*; about 500′ in thickness.		
		f_1. Dark crumbling shales with limestone partings thickness about 400′.	Lower.	
		f. Hard dark limestone with *nummulites*; thickness about 1,200′.		

Both in the Pannóba and the Trakhobai valley this sequence may be observed. The nucleus as it were of the section is formed by the hard grey nummulitic limestone (f) which is in greatly disturbed position, dipping under a high angle (from 60° to 80°) to north below the shales (f^1). A double ridge of this limestone runs between Pannóba and Trakhobai, showing a steep dip-slope along its whole northern side. This limestone ridge is greatly jointed, and shows at least two long lines of fault,—the northern one, which is crushed much, producing no great throw either side, whereas the southern one forms the boundary between the nummulitic limestone and the red (Murree) sandstone beds (*g*). The rest of the section is simple; it is a normally ascending one to the north, both at Pannóba and all the intervening points. The hard limestone (f) is overlaid by dark, crumbling shales (f_1), which have not yielded any fossils at all.

Description of sections.

[1] See figs. 6 and 7, pl. 2.

About a quarter of a mile west of Pannóba village, some lenticular deposits of these shales are interstratified between massive beds of the nummulitic limestone (f). The latter is raised up vertically, but the dip gradually lessens westwards to 65°, varying considerably at short distances. The shales, being easily disintegrated, have been denuded away along the strike of the bede; hence the longitudinal valleys of Pannóba and Trakhobai, which are separated by a low saddle about halfway between the two villages. The shales rest, as said, conformably on the limestone (f); they vary considerably in lithological character from greenish grey clay shales in which indistinct fucoid markings are discernible to very dark alum shales. Ferruginous and calcareous partings are common throughout the thickness and near the "saddle" which connects the two valleys. I noticed partings and vein infiltrations of gypsum in the shales (f_1), which are weathering of a rusty brownish yellow. The limestone (f) forms a crushed fold in the Trakhobai valley, the dip turning round from north-west to south-west. Round this termination of the crushed fold, the shales (f_1) are placed conformably to the former; and in a loop of the ridge of the Narai Sir, which corresponds to the fold of the limestone, the ascending section from the shales (f_1) to the Murree beds (g) may be seen very plainly. The top of the Narai Sir ridge is formed of the upper eocene limestone (f_4) which also contains *nummulites* in every bed, and this division is conformably overlaid by the densely red beds of the *Murree* series (g) which follows north-west and which I crossed in the low spurs south of Lakhotalao.

Pannóba village itself is standing on the shales (f^1) which contain a good deal of gypsum in leaflets. The shales have some partings of flaggy limestone, breaking with conchoidal fracture; they are overlaid by hard grey limestone (f_2) which contains many minute organic remains, mostly foraminifera, and distinct *nummulites*. North of Pannóba the sandstone beds (f_3), which are best seen in Narai Sir section, are replaced by brown and olive-coloured shales with thin bedded marls and a few sandstone beds. This division is followed by the upper *nummulitic* limestone (f_4) of the Narai Sir range.

The dip is very rolling. The beds which form the Narai Sir range dip pretty steadily 40° to 45° N. W. and N. On the other hand, the shales (f_1) are greatly crushed, and the limestone ridge between Pannóba and Trakhobai is formed (see figs. 6 and 7) by crushed limestone beds. Near the south-western portion (fig. 7) the limestone (f) dips below the shales under an angle varying from 60° to 80,° whilst at Pannóba itself this bed is nearly vertical; and about 200 yards below the village, the dip has turned to south-east about 74°, but this varies a great deal more nearer the fault, which may be traced along the entire southern slope of the well marked double ridge between Pannóba and Trakhobai.

The limestone (f) is a hard nummulitic rock, with masses of earthy bituminous limestone, both full of organic remains, chiefly small bivalves (*ostrea*), but also great quantities of *nummulites* and small corals and organic detritus impossible to determine. The colour is generally a dirty yellowish brown, with harder grey beds of limestone.

Petroleum.

About half a mile below Pannóba village the limestone shows evidences of great crushing; and at least two clear faults may be seen, no doubt continuations of the Trakhobai dislocation. There, in joints close to the northern line of fault some oil oozes out in thick drops which collect on

the surface of three pools formed by the Pannóba stream. With it issue several very salt springs, charged with sulphuretted hydrogen gas. The quantity of the oil issuing from the springs is very small; and, I am told, varies from a few ounces to about two quarts daily. The natives collect the oil floating on the pools of water by sopping it up by means of straw-wisps, which are then squeezed dry by hand. The oil so obtained is of course mixed with a great deal of impurities, is of dark brown colour, and very thick. I could not obtain enough for an assay even during the several days I stayed there. The stream was then very full of water owing to rainy weather, and the oil could not collect on the pools in sufficient quantities, as the latter were continually draining off.

Fault.

Some 150—200 yards further south-east, the great fault shown in both sections (figs. 6 and 7) has cut off the limestone and brought it into direct contact with a series of the Murree beds (g) which are not arranged in the numerous anticlinals shown in Mr. Lyman's report, but form a normally ascending section dipping under an angle of from 40° to 50° north *against* the fault.

It is the same section seen near the southern half of the Ungo pass, namely a sequence of sandstones of more or less red colour with intercalated sandstone and subordinate limestone beds of the Murree series of Mr. Wynne, (Upper Subáthu of Dr. Waagen).

The fault is best and clearest seen on the right side of the valley, immediately below the oil-springs; it is accompanied by a great deal of minor disturbance and crushing of the strata. Some 70 to 90 feet of the section is entirely formed of slipped and crushed masses, whilst the dislocation is partly filled by a very distinct fault-rock —a breccia of limestone and red sandstone blocks and debris cemented together by a calcareous matrix. The same may be observed near Trakhobai west-south-west of the oil-springs.

I have not heard of any other trace of oil in the neighbourhood; nor are there any other indications visible within these two valleys, which would point to the presence of earth-oil, as far as I have examined the ground.

V.—*Concluding Remarks.*

In the preceding pages I have given all the information which we possess at this present moment, concerning one of the most important mountain ranges of Áfghánistán. The main points which result from a consideration of the information are the following:

Orographical features.

The Saféd Kóh forms a distinct line of ranges running almost due east and west, which continued westwards meets the line of the Hindu Kush at an angle of 45°, in the great mountain mass west of Kábul, within which the Kábul river drainage, the Helmund, and the Kunduz river (Oxus drainage) take their rise. The Kóh-i-Bábá, though possessing the same strike as the Saféd Kóh, cannot rightly be considered to belong structurally to the same system of elevation, as it differs in its past history from the latter.

I divide the system of the Saféd Kóh into three distinct orographical areas, namely:—

1. The main axis, starting north-east of Ghazni in Áfghánistán and ending west of Peshávar on the Indian frontier.

2. The northern skirting ranges, which, running parallel to the Saféd Kóh, accompany the latter in one or more distinct ranges, more or less closely connected with it, and forming the Siáh Kóh, the Besúd and Kúnar ranges, the Khaibar hills, and they are probably continued, at all events are closely connected with the ranges of Bajoúr and Buner.
3. The southern skirting ranges, which start in Kharwár in Áfghánistán, run parallel with the main axis of the Saféd Kóh, and are continued eastwards as the Urakzai hills, the Afridi ranges, and finally end on the Indus at Attock, and south of it in a series of lower ridges.

How far and in what manner these latter are knitted to the Waziri hills south of the Kuram is at present impossible to say. I believe however that a close connection will be discovered.

Structure.

The orographical features as related here are conditioned by the geological structure of the ranges. The latter is that of a succession of reversed flexures, their longer shoulder dipping northwards and divided by at least two great systems of dislocation.

The northern skirting ranges, I believe, will be found to consist of old metamorphic rocks with palæozoic; much altered strata following as a belt south of it, and possibly some strata of the older mesozoic wedged as narrow strips into the belt of the latter (see Khaibar hills).

The main axis belongs probably to the older palæozoic group.

The southern skirting ranges are chiefly formed by the mesozoic group, with a preponderance of its younger systems.

Faults.

At least two systems of dislocations run parallel with the strike of the Saféd Kóh: the northern marked by a long line of igneous intrusive rocks, which may be traced from east of Kábul to the Khaibar hills; the southern one, very plainly shown in the Kharwár and Shutargardan area in Afghánistán, where it is also accompanied by igneous intrusive rocks, whilst its continuance eastwards into the Afridi hills can only be conjectured by the peculiar structure of hills seen from afar and the intrusions of igneous rocks near the Ublán pass and Kohát ranges. Within the easternmost termination of these ranges (Cherát and Ungo pass, also Sandlai?) there are numerous minor faults, which are probably continuations of the same system of dislocations.

Sáfed Kóh not part of the Hindu Kush system.

The Saféd Kóh is distinctly not a part of the Hindu Kush system; orographically speaking, it differs in strike, and structurally it is not analogous to the latter. The Hindu Kush contains within its flexures a series of marine miocene beds, which take part in all the contortions and flexures which have affected the older rocks. The Hindu Kush therefore dates in its entirety from post-miocene times, whilst within the Saféd Kóh system there is no marine formation interposed between the later nummulitics (Murree series) and the Siwaliks. The elevation of this area was therefore finished, or at all events sufficiently so to form dry land, in miocene times, together with the ground north-east of it, the Himálayan system.

The Saféd Kóh forms the wrinkles of sedimentary strata along the southern margin of the ancient *terra firma* of Swát, Dír, Kafiristán, Chitral, and the countries north of it; the real Hindu Kush, (the south-western portion of it) forms the western fringing wrinkles to this firm crystalline massif.

Junction between cretaceous and tertiaries.

The junction between the upper cretaceous and the nummulitics along the Urakzai and Afridi hills is a normal one, *i.e.*, the nummulitics rest quite conformably on the former.

No overlap in cretaceous.

There is no unconformity or overlap observable between the cretaceous and the upper jurassic (or neocomian?), as is the case in Turkistán and Persia.

Dág beds not Attock slates.

Finally, I may state that from personal observation of the section between the Peshâwar plain and Mir Kálan, I am forced to the conclusion that the palæozoic age of the series of beds near Dág, described by Waagen as Attock slates, is very doubtful. Their present position would incline me to the belief that they are rather of later eocene age, and possibly a *flysch* facies of the upper Murree series. They are plainly conformable to the Murree series at Dág.

Petroleum.

The only locality within the area described in this paper where earth-oil has been found is the narrow valley of Pannóba in the Kohát district. These oil-sources have been known for some time past, and have been specially reported on in 1870 by Mr. B. S. Lyman in his report already cited. The geological details given by this expert are incorrect, and his speculations with regard to the distribution of the oil in the strata exposed are without foundation, whilst his view that the oil found in a certain stratum being *entirely confined* to the latter is certainly erroneous, though I agree with him in believing that the oil of Pannóba belongs probably to the horizon in which it is found, *i.e.*, in other words the oil is there in "primary deposition."

The only facts which I was able to collect on the spot regarding this find of oil are stated in Chapter IV. They are shortly these:

The oil issues along joints in earthy, and near the springs, bituminous, nummulitic limestone, which joints occur within a few yards of the crushed fault shown in figs. 6 and 7 of pl. 2. I did not find any oil traces along the main fault itself, but the latter is so much obscured by detritus and crushed rock that oil traces may very well exist below the latter without showing on the surface itself.

There is no other oil horizon known in the neighbourhood as far as I have been able to ascertain.

The oil traces, such as they are, occur therefore in a highly disturbed area, issue actually along lines of fracture and near the northern half of what would have been an anticlinal, if the fault had not lowered the entire upper eocene (Murree series) down to the level of the nummulitic limestone (f) which dips under a high angle to the north.

Modern researches have shown, and so far almost without doubt, that anticlinals favour the accumulation of oil beneath them, if oil exists at all in the strata below an impervious cover. This view has been held for some time past, and it was Professor Hans Höfer who was the first, I believe, who showed that the principal oil sources of Canada, Ohio, Western Virginia, etc., are collected below great lines of anticlinals[1]. This view has since been adopted and expanded by American and foreign scientists.

I need not go further into this matter (which has been threshed out by numerous authors[2]) or point out the various objections to this theory which have been urged

[1] Die Petroleum Industrie Nord Americas, 1876, pp. 81 and 82.

[2] See also R. D. Oldham: "Memorandum on the Mode of Occurrence of Petroleum, Calcutta, 1891.

with more or less success. These must occur to every thinker; the natural objection that along lines of anticlinals fissures often occur, and that, therefore, oil-sources are more frequent along anticlinals is true enough without doing away with the factt that if the oil proceeds upwards owing to internal pressure, it must needs follow tha the most favourable rock structure to arrest the upward flow of oil is the anticlinal fold or dome, if protected by an impervious bed, and underlaid by porous strata, forming as it were an oil-sponge.

This granted, it must follow that the amplest supplies of oil must be more or less of "secondary deposition" (H. Hofer)—an 'interloper," as H. B. Medlicott[1] calls it. But, apart from the mechanical fact that oil must accumulate under favourable conditions under such anticlinals, we may form some opinion regarding the Pannóba oil traces in the light of what has been recorded of other oil localities.[2]

The oil oozes out at Pannóba, not along the crest of an anticlinal, but from out of joints in limestone close to a long line of faults. But this does not prove that this system of faults has not tapped a larger accumulation beneath an anticlinal in the strike of the flexures. Possibly there is somewhere such an accumulation; and probably the immense compression which the beds must have suffered, and, it is imaginable, are still undergoing, is not only forcing the oil into convenient receptacles, but also is slowly squeezing dry the "oil-sponge," whatever the latter may be, and hence causes this steady supply, small though it may be, of the oil along the lines of joints. So far the sources of the oil might be sought for anywhere; and it migbt he conjectured that, under favourable structural conditions, a larger supply of oil could be expected.

Much was hoped of the oil supplies' of the Punjab, and trial borings have been made here and there, but all without any great success. Everywhere only traces of oil have been obtained, but, on the other hand, a considerable amount of experience was gained. It appears that oil traces are only found within the eocene rocks in the Punjáb, or rather have not been discovered beneath the latter. Not a single case of oil traces occurs, as far as I am aware, in strata older than eocene in the Punjáb or countries across the border, nor in the sandstones and shales younger than nummulitic. The oil is therefore certainly, as regards the base rock of the eocene, the nummulitic limestone, in "primary deposition," though it might either be "connate" or "innate," contemporaneous or metamorphic, in its origin.

I myself believe that, until facts contradicting the view are discovered, the oil traces of Pannóba, and indeed of the Punjáb generally, must be associated with the enormous mass of organic matter which has contributed, and in some cases has even formed the eocene beds of these sections.

It is impossible to view the mass of the nummulitic strata of these hills, especially the limestones of the lower eocene, partly of coralline origin, partly simply filled with nummulites and other foraminifera, without being forcibly reminded of the interesting description given of the coral reefs of Jebl (Djebel) Zeit in the Red Sea by Dr. Oscar Fraas.[3] There, a formation of petroleum is closely connected with the coral reefs.

[1] Records, Vol. XIX, p. 190.

[2] Hans Höfer: "Das Erdöl." Braunschweig, 1880, 8vo. The learned author has in this book collected a vast amount of information concerning earth-oil and its nature.

[3] Aus dem Orient, Stuttgart, 1867, 8vo, pp. 191 to 195.

The oil-wells occur opposite El Tôr on African soil; and, together with the sulphur of Ras Gimsheh (south of El Tôr) are leased to the Marquese de Bassano. They are situated near the foot of a porphyry scarp, along which the coral reefs extend. The wells are simply holes dug out of the reef not far from the shore and below the level of the sea. As usual, there are exhalations of sulphuretted hydrogen; the oil collects as a greenish thick mass, several inches high on the surface of the water in the holes, and is there collected into glass vessels.

Fraas does not doubt that the oil originates in the coral reef: the latter near the sea-shore is completely impregnated by bituminous matter, and oil trickles out in single tears and drops, whilst it rises to the surface of the water (the latter generally of about 90° F. temperature), being of lesser specific gravity. The lagunes are simply filled with organic (chiefly animal) life; its water never sinks to a lower temperature than 73° F., and is generally above this figure. There is a constant decomposition going on with the formation of gases, whilst no doubt, the heavier hydro-carbons condense as oils.

A very good proof that the oil does not originate away from the coral reef is found in the experimental workings carried out by the Superintending Engineers of the Oil Company. Concluding that the oil rose along the contact between the coral reef and the porphyry scarp, a trench was dug right across the reef into the scarp itself, to a depth of about 30 feet. It was found that the reef away from the sea does not contain a drop of oil or even bituminous matter, nor is there any oil found along the contact. Not even the water penetrates into the close coral limestone, which appears white and dry on both sides of the trench, 3 feet wide and 30 feet deep. Only close to the living coral bank below the level of the sea is oil found to exude from the reef.

Similar finds of bitumen (with sulphurous springs) occur in many localities of the cretaceous and tertiary rocks of Egypt and Palestine. The sulphurous springs of Hamam near Tôr in the Gurhundel near Suez occur all in the old reef, and probably the higher temperature of the rocks is owing to the bitumen which it contains and which is constantly decomposing.

It seems clear that the occurrence of salt, gypsum, and sulphur is closely connected with the formation of oil in the lagunes. Not far south of Jebl Zeit the coral reef formation constitutes a wider belt along the sea-shore, and within are found sulphur deposits which alternate with gypsum and salt layers. The sulphur occurs in nests and veins in the gypsum, much in the same manner as does the sulphur of Girgenti in Sicily, although the latter belongs to an older tertiary horizon. So much from Dr. Fraas.

It is impossible not to be struck with the possible connection of the petroleum contained in the Punjáb tertiaries with the immense mass of organism which have contributed to the formation of the lower eocene in that area. If the oil has originated in the coral lagunes and nummulitic seas, I believe it must have been absorbed within coast formations (sand-dunes probably) which have acted as oil sponges as it were, and which would now form strips within the eocene series of beds in North-Western India. Compression of these formations into flexures and resulting pressure may have squeezed the oil into other and more favourable receptacles for instance below anticlinals; or have forced it to ooze out along lines of fissure, but, nevertheless, I believe it to be contemporaneous with the eocene strata. I may

here mention that Mr. Townsend's description of the Kháttan oil locality favours the view "that the oil is indigenous in these eocene rocks, probably in the shales that are described as so densely charged with organic remains, although the associated fractured limestones have afforded in their crevices convenient receptacles for the oil. I certainly think that this view should be the one adopted for immediate operations." [1]

If this view be adopted for the oil-sources of the Punjáb, it only remains to consider whether the indications warrant any hopes of a larger supply of oil being discovered at Pannóba or elsewhere within the tertiary system. I confess I am not sanguine that such may be the case. The thickness of the lower eocene, rich in organic remains, is not very considerable, and seems altogether of local distribution as might, indeed, be supposed of a coralline formation. It occurs also more or less as a long strip, following in some degree the strike of the lower ranges of the Saféd Kóh and the southern margin of the North-Western Himálayas; which strip has been extensively disturbed, crushed, and faulted, and it may therefore be presumed that much of the oil supply has been run to waste through fissures. Certainly, however, there is none at all; and this being so, I think that it is advisable to continue the geological exploration of the area, and even to carry out trial borings in places which would promise most success; perhaps it will be found that further away from the disturbed area such a locality may be discovered. I am not hopeful of great results, but the attempt should certainly be made, to settle once for all whether there are any productive oil-measures in the Punjáb. One would not have to look below the eocene strata for such.

CAMP MANMAW,

UPPER BURMA;

5th January 1892.

[1] H. B. Medlicott: Records, Vol. XIX, p. 201.

Report *on a* Survey *of the* Jherria Coal-field, *by* THOMAS H. WARD, Assoc. Mem. Inst. C.E., F.G.S., *Assistant Colliery Manager, East Indian Railway.*[1] (With a map and 3 section plates.)

Pursuant to Dr. Saise's orders—to make a definite report on the economic resources of the coal-field—operations were commenced on March 8th, 1890, and were carried on until the rains broke on 27th June.

The western extremity of the field lies about 13 miles to the south of Parasnath Hill, and the northern boundary is for some miles parallel to, and about 4 miles south of, the proposed Grand Chord Line.

I had the assistance of Mr. T. W. H. Hughes' report and map (Memoirs, Geological Survey of India, Vol. V, Pt. 4). It will be seen that I have greatly modified the area represented as being occupied by the Raneegunge and Iron Stone shale groups, and I have succeeded in correlating all the seams in the main portion of the area and in working out all the principal faults.

A few brief remarks in reference to the structure of the field and in explanation of the sections now submitted are necessary.

Cross section No. 4 (Plate 3) shows the general structure of the field.

The groups exposed, named in descending order, are—

(1) Raneegunge 2,500 feet:
(2) Iron-stone shale—600 feet in west (Jamooni section) and 1,600 feet in east (Chatatand section),
(3) Barákar, about 3,000 feet.

(1) The Raneegunge group occupies 28½ square miles in the south-west corner of the field. No seams of interest were met with, and no effort was therefore made to correlate them.

(2) The iron-stone shales underlie the above and spread to the north and east. On the west they disappear under the great fault (shown in cross section No. 5 and on map), which in the Jamooni has a throw of about 1,600 feet. To the east they thicken out from 600 to at least 1,600 feet, and occupy all the area on the south of the field up to the southern boundary fault (see cross section No. 1 and map).

(3) The Barákar group again underlies the above and spreads still farther north and east, occupying the whole area of the coal-field, 150[2] square miles. It contains 17 seams of coal, of upwards of 5 feet in thickness. A reference to cross sections 2, 3, and 4 will show that in the main central area these measures "dip" at an angle—very moderate from a mining point of view—of 10° to the south, whilst on the flanks east and west (cross sections 1 and 5) the dips increase to 30° and 40°. The base of the Barákars, it will be seen, attains a depth of over 6,000 feet below the surface on the south-west of the field and of about 5,000 in the south-east. Cross sections 2 and 3 have been given to illustrate the interesting

[1] Through the courtesy of the Agent of the East Indian Railway, this report is allowed to appear in these Records. It is of great interest as following on the survey made so many years ago by Mr. T. W. H. Hughes.—ED.

[2] Excluding the Talchir group.

series of "strike" faults which has rendered the Busjoria and Basreya sections so difficult to work out, and the comprehension of which is essential to the object of the survey.

The high dips at Chasnalla (No. 1 section) and the heavy faulting in the Kunjea Jor[1] are due to the great upheaval which concentrated itself along an east and west line running through Bhatdeeh and north of Chatabad, and which, tearing through the coal strata on the north (Radhoochuck and Soorunga), turned the edges of the southern fragment of the field up to daylight.

The fault marked by a dotted line near Burhemusiya (east of Doomra) seems the most probable solution of the structure there. I had to abandon the field while investigating this problem.

In the plan I have omitted all reference to trap dykes. The map of the Geological Survey of India, where Mr. Hughes has carefully mapped nearly all, can be referred to for information. Structurally they are of course of secondary importance. In the main central area and to the east there are fewer dykes than in similar areas in the Raneegunge field. To the west they increase in number and size, but there is no reason to suppose that they do more than (as is the case in the Kurhurbaree and other fields) locally affect the seams they pass through.

One striking feature of the field is the burnt out-crops. These aggregate many miles in length, and the burning of the great seams of coal—as for instance in the vicinity of Jherria Khas—has altered and slagged down the superior shales and sandstones until the desolate and cinder-strewn localities appear at first sight to have had a volcanic origin. In no case, however, has the cause of combustion been due to intrusion of volcanic matter.

Turning to the sheet of vertical sections (Plate 2) it will be seen that I have numbered the seams from the base upwards, and that any of the seams can be easily identified on the plan by these numbers. Nine vertical sections are shown, and these have been compiled from the horizontal sections exposed in the various rivers after which they are named.

As the sections of the Bugdigi and Katree abruptly end against the north boundary fault, it is only possible to surmise the manner in which the enormous seams Nos. 2 to 4 splits up to the east.

As above stated, 17 seams of coal have been traced out. It is unnecessary to refer to each of these seams. Suffice it to say that all were scrutinised and samples from such as presented an encouraging appearance subjected to analysis.

This brings me to the main question, the quality and available quantity of steam coal.

No. 13 seam contains a very fine quality of coking steam coal, so superior to the quality of coal in the rest of the seams as quite to discount any value they might otherwise have possessed.

In following this seam from west to east it will be seen from the sheet of vertical sections that it thickens from 8′ 0″ to 55′ 0″.

On Plate 1, I give 7 sections of this seam showing the changes it undergoes from west to east—27 miles—and also the quantity of ash contained in various sections.

[1] It has been impossible to give greater detail on the small scale map.

The quantity of coal available from this seam, containing less than 13·5 per cent. of ash (the great proportion of the coal containing about 11 per cent.), is:—

(1)	At depths less than 800 feet and "dipping" at less angles than 12° and in a seam from 8-0 to 15-0 in thickness	157	million tons.
(2)	Ditto ditto at angles from 12° to 55°	56	" "
	Total quantity down to 800 feet .	213	" "
(3)	At depths below 800 feet the greater portion dipping at about 10°	877	" "
	TOTAL	1,090	

The above is the gross quantity. As the quantity under head (1) is very favourably situated for mining, a deduction of 20 per cent. will be ample for loss in working. Similarly 40 per cent. should be deducted from head (2), leaving a total nett available tonnage at a less depth than 800 feet of over 159 million tons.

I append a table showing the chemical composition of the coal in the Jamooni and Perghabad Sections of this seam, and comparing them with an average sample of Khurhurbaree coal:—

	Volatile constituents per cent.	Fixed carbon per cent.	Ash per cent.	Calorific power.	REMARKS.
No. 13 { Jamooni . .	28·29	58·24	13·47	......	{ 13·3 lbs. of water evaporated from 212° per lb. of fuel.
No. 13 { Perghabad .	29·80	60·00	10·20	13·30=	
Kurhurbaree[1] .	24·00	66·84	9·15	13·20=	13·2 ditto ditto ditto.

The calorific tests are by Thomson's calorimeter.

These results show that in chemical constitution and evaporative power this coal is nearly allied to the Kurhurbaree coal. The ash shows no tendency to clinker.

Such a coal is much superior to the general average of the raisings in the Raneegunge coal-field, and when the Grand Chord Line is built would command the North-West market. It will be 75 miles nearer to Moghal Sarai than Giridíh coal, and will have an advantage of from 25 to 30 miles over Barákar coal.

No. 12 seam.—In the centre of the coal-field, for nine miles, this seam contains valuable fuel in a seam from 5 to 6 feet in thickness. Towards the east, bands of shale appear, and to the west the seam appears to get poorer. These facts greatly curtail the area over which the seam can be safely estimated. The figures below are well within a safe margin.

The quantity of available coal from this seam, containing less than 14·25 per cent. of ash in sections over 5 ft. thick, is—

(1)	At depths less than 800 ft. and dipping at a less angle than 12° gross	46,653,000		
	Say nett	......	37	million tons.
(2)	At greater depths than 800 ft. and dipping at 10° or thereabouts	......	150	" "
	TOTAL NETT AVAILABLE		187	

[1] From one of Dr. Saise's reports.

I have given 3 sections of this seam, and below is an analysis of the seam at Ekra:—

	Volatile constituents per cent.	Fixed carbon per cent.	Ash per cent.	REMARKS.
No. 12 seam, Ekra	26·28	61·36	12·36	The coal from this section did not coke. That from all other sections coked well.

The constitution of this coal indicates that it is a good steam coal.

No. 17 seam was examined only at Seetanalla (on the east of the field and south of the Damuda), where it contains a valuable fuel. Analyses of the whole seam, which is there 10 ft. thick, gave the following results:—

	Volatile constituents per cent.	Fixed carbon per cent.	Ash per cent.	REMARKS.
Seetanalla, No. 17 seam	32·19	57·58	10·23	Samples all coked.

A glance at the map will show that in the central part of the field this seam shows itself infrequently. It was not until towards the end of the survey operations, and when it was too late to take steps to test it further, that the value of this seam was noticed. The information available is therefore insufficient to enable its economic resources to be estimated.

Tabulating results we have—

Reference to seam.	At depths down to 800 feet.	At depths greater than 800 feet.	
No. 13 (10°)	157,000,000	...	
(10°–55°)	56,000,000	877,000,000	
No. 12 (10°)	46,600,000	150,000,000	
Gross	259,600,000	1,027,000,000	
Total gross	...	....	1,286,600,000
Nett available as per previous remarks.	196,000,000	668,000,000	
Total nett available	...	...	864,000,000 tons.

None of the other seams claim notice here. In some of the sections good coal was met with, but always in association with inferior coal.

The above enormous quantity of valuable steam coal is situated in a district where labour is plentiful—from which in fact thousands of coolies are annually deported to Cachar and Assam. A leavening of the population also has already gained some experience in coal mining in the neighbouring districts.

GIRIDÍH:
August 7th, 1890.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 11.—ENDING 30TH APRIL 1892.

Director's Office, Calcutta, 30th April 1892.

The field working season is about coming to a close, but the disposition of the Survey staff stands as reported in the previous note; namely—

Lower Burma.—THEO. W. HUGHES, A.R.S.M., Superintendent.
P. N. BOSE, B.SC., 2nd grade Deputy Superintendent.
Upper Burma.—C. L. GRIESBACH, C.I.E., Superintendent.
FRITZ NÖETLING, Ph.D., Palæontologist.
P. N. DATTA, B.SC., Assistant Superintendent.
Punjab.—T. D. LATOUCHE, B.A., 2nd grade Deputy Superintendent.
C. S. MIDDLEMISS, B.A., 2nd grade Deputy Superintendent.
W. B. DALLAS EDWARDS, A.R.C.S., Assistant Superintendent.
Madras.—T. H. HOLLAND, A.R.C.S., Assistant Superintendent.
Head Quarters, Calcutta.—The Director; and R. D. OLDHAM, A.R.S.M. Superintendent; and F. H. SMITH, A.R.C.S., Assistant Superintendent.

Mr. Holland having completed the examination of the iron conditions in the districts of Arcot, Chingleput, Coimbatore, Madura, Malabar, Nellore, Nilgiris, Salem, Tanjore, Tinnevelly, and Trichinopoly, returned to head-quarters temporarily. The investigation will be resumed in Mysore, the Central Provinces, and remaining principal iron-bearing tracts in November. In the meantime, Mr. Holland has prepared a preliminary report on the iron resources and native smelting industries of the Salem district; and a preliminary Hand-Book on the Iron Ores of the Madras Presidency is in preparation for the Imperial Institute. In this connection, the discovery of the manufacture of steel by the decarbonisation of cast-iron shot by the Kattipariahs in the Salem district, as compared with the wootz-making industry of the Trichinopoly Karumans, is a point of considerable metallurgical interest.

From the Burma parties the reports of progress show that the tin exploration under Mr. Hughes is approaching sufficient completion to allow of leasing and opening up to the full extent of any applications in that way which are likely to come before the Government for some years to come. The prospecting field parties will be called in by the 15th of May, when the question of further exploration on such lines will be considered. Concomitant with the tin search on the upper Tenasserim

river, Mr. Hughes has made some important investigations in the coal occurrences in that direction; so much so, that he had been able to despatch some raft-loads of promising coal down the river for trial in the coasting S. S. "*Mergui*" and the prospecting launch.

In Upper Burma, Mr. Griesbach accompanied the north-eastern column and explored the country lying between the Upper Irrawaddi and the Chinese frontier; Dr. Nöetling was attached to the Maingkwan column, and visited the amber and jade mines; while Mr. Datta was engaged in the Thayetmyo district.

In the Bhamo district, the country north and north-east of Bhamo is chiefly formed of crystalline rocks occurring in a series of flexures running more or less north and south. A few strips of sub-metamorphic rocks, probably of palæozoic age, occur within these folds; amongst them is a crystalline limestone which may be expected to have yielded the spinels which are found in the Irrawaddi alluvium. Patches of younger tertiary rocks are found here and there, which contain lignite in beds of 3 to 4 feet in thickness, as to the west of Mogoung, and again, to the north of that feature of the upper Irrawadi drainage called the "confluence."

Gold is found all over this country in the recent deposits, and is actually washed for by the natives, through in a very primitive fashion. The very extensive alluvial "flats" between Hokat and Watu on the Irrawaddi are rich in gold; so that it seems as if there were here a more decidedly favourable prospect of a successful "placer" tract than has yet been noted in the Indian Empire. Mr. Griesbach has suggested to the Government of Burma the expenditure of a considerable sum of money in order to ascertain the extent and capabilities of these auriferous deposits; a proposition which will receive due consideration. Spinel, in the form of small rounded crystals, is profusely scattered through some of the alluvial deposits, increasing somewhat in size in the neighbourhood of the "confluence" above referred to; the inference being that they have been derived from limestone beds which occur some 20 miles north of this locality. Associated with these spinels are splinters of what Mr. Griesbach considers to be rubies, though they were too small for field identification. Some few small crystals of ruby are said to have been found by natives to the north of Watu.

The jade and amber mines were visited by Dr. Nöetling with apparently favourable results, though his report has not yet come in.

Although the lignitic coal mentioned above as occurring some 10 miles west of Mogoung is only in poor seams, it will no doubt have an important value when the railway to that place shall have been completed. Similar seams, of about 3 feet in thickness, are reported as occurring near Talang, north-west of the confluence; some samples of which have been burnt in the Government river steamers with satisfactory results.

In the Thayetmyo district the survey of the country between the town of that name and the Arrakan coast was left to Mr. Datta, Mr. Griesbach having subsequently inspected the work.

His report on the main results is, that there is a complete sequence of strata between the eastern slopes of the Arrakan Yoma and the Irrawadi river, from coarse sandstones and grits (upper cretaceous probably) to the younger tertiary deposits of the Irrawadi Valley. Especially well developed are the eocene beds, which are

richly fossiliferous and occupy the whole breadth of the eastern slopes of the Arrakan Yoma, a portion of which was formerly considered as of triassic age ("Axial Series" of Theobald). This further evidence as to the occurrence or non-occurrence of triassic rocks in this region is of the highest importance; but it is as well to notice the fact that a triassic age was only attributed to these rocks on certain somewhat questionable fossil data. Indeed, the "Axials" were originally considered by Mr. Theobald as comprising the oldest tertiary beds and their immediate predecessors in the series.

Some unimportant oil wells west of Thayetmyo were visited by Messrs. Griesbach and Datta.

On his return from his deputation with the Maingkwan column, Dr. Nōetling resumed work at Yenangyoung in connection with the settlement of the oil-leases in that district. A most interesting feature of this officer's later work in this region are the reported finds of tertiary fossils, and among these the remains of bird-like jaws with teeth.

Towards the end of March the Director visited Baluchistan and approved of a site for a further experimental boring for oil in the Chuppar Rift, the works at Khattan having been finally abandoned owing to the unfavourable results obtained in the crucial boring suggested by Mr. Oldham in the Siah Kutch plain. The Chuppar Ramu, which is a huge ellipsoidal domoid, or whale-back, ridge crossing the north-west end of the Harnai valley, is cut right across its middle by a deep gorge, or "rift," up which the Sind-Pishin Railway runs. Thus, some 600 feet of the over-arching nummulitic limestones of this great anticlinal have been scooped out across the longer axis of the dome, exposing the underlying belemnite shales; the series so exposed by denudation answering, as closely as can be inferred, to that penetrated by the borings at Kattan. It is presumed that this Chuppar anticlinal offers conditions for holding oil under a nearly perfect and unbroken cover. With the advantage of over 600 feet of the covering limestones having been removed by denudation, there is also the fact of only the merest traces of oil-shows having been reported by the engineers during the cutting and tunnelling of the railway, which points not only to the existence of an oil source under this dome, but to the probability of its having only the slightest opportunities of issue. On these grounds, the site for boring has been selected on the exposure of the belemnite shales in the bed of the rift; and it is expected that the possibilities of the site as a source of oil will be ascertained within a range of 700 to 1,000 feet, probably within the lesser depth.

The proposal initiated by Professor Ed. Suess, of the K. K. University of Vienna, to send out Dr. Carl Diener to collect and study the fossiliferous beds of the triassic formation in the Central Himalayas, in colaboration with the Survey, having been accepted by the Government of India, and Dr. Diener having arrived in India, the expedition is being prepared to start early in May. The Survey will be represented by Messrs. Griesbach and Middlemiss, the former officer being in charge of the party.

Consequent on the retirement of Mr. Foote, Mr. R. D. Oldham has been promoted to Superintendent, and the vacancy caused in the third grade has been filled by Mr. F. H. Smith, Associate of the Royal College of Science.

List of Reports and Papers sent into the Office for publication or record during February, March, and April, 1892.

Author.	Subject.	Disposal.
F. R. MALLET	On the locality of Indian Tscheffkinite.	Will appear in the Records, Geological Survey of India, for August next.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April, 1892.

Substance.	For whom.	Result.
Galena with quartz	M. F. LAVELLE, for Gillanders, Arbuthnot & Co., Calcutta.	Assayed for lead and silver.
Four specimens of quartz	Dr. R. C. SANDERS, Calcutta.	Assayed for gold.
Two specimens of phosphatic nodules from Utaloor, Trichinopoly district.	Dr. H. WARTH, Officiating Superintendent, Government Central Museum, Madras.	Specimen "No. 4." Qantity received 1½ oz. Contains 26·5 per cent. of phosphoric anhydride (P_2O_5). Specimen "No. 5." Quantity received 1½ oz. Contains 29·55 per cent. of phosphoric anhydride (P_2O_5).
"Three stones and a small box of earth" from the Matral of Katwaz, for determination.	WALSH, LOVETT & Co., for His Highness Amir of Afghanistan.	Psilomelane. Decomposed gneiss.
A box of minerals and rocks for determination, for Museum, Lahore.	Chemical Examiner to Government Punjab, Lahore.	1. Fine grained crystalline limestone with calcite. 2. Barytes. 3. Green pyroxene (Diopside). 4. Calcite. 5. Copper pyrites in quartz (3 specimens). 6. Limestone with garnets and spinels. 7. Calcareous sinter. 8. Decomposed rhyolite. 9. Shale with calcite veins. 11, 13, 26, 45. Quartz with tourmaline. 12. Pink calcite with chlorite. 15. Copper pyrites in quartzite. 15. Calcareous rock. 16. Copper uranite. 18 (i). Native arsenic. 18(ii). Decomposed basic igneous rock, with chloritic material and magnetite. 19 (i). Quartz with trace of haematite. 19(ii). Jasper. 20. Calamine.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April, 1892—continued

Substance.	For whom.	Result.
		21. Galena.
		22. Galena and copper-pyrites in quartz (3 specimens).
		24. Galena in quar z (2 specimens).
		26. Ditto ditto.
		23. Specular iron ore, Nos. 35, 27, 53 (2 specimens), 54, 55, 56, 57, 58, (2 specimens), 64, 68, 103 (i), 104, 71.
		24. Flint.
		25. Cobaltine (2 specimens).
		28. Pyrolusite.
		29. Strontianite.
		30 (i), 79. Scoriaceous basalt with biotite inclusions.
		30(ii). Quartz with pyrites.
		31. Quartz with barytes.
		32. Calcareous sandstone.
		33. Quartz on haematite.
		34. Sandstone (shale), with lignite (Siwaliks).
		70. Ditto ditto ditto.
		38. Iron pyrites decomposing.
		40. Malachite.
		42. Copper pyrites in quartz.
		43. Natrolite.
		44. Psilomelane.
		46. Opal in calcareous rock.
		47. Oxide of lead.
		49. Calamine.
		51. Lithomarge.
		52. Pyrolusite.
		59. Barytes.
		60. Magnesite.
		61. Gypsum.
		62. Barytes with galena (2 specimens).
		63. Albite with superficial deposit of chloritic material.
		64. Felspar—plagioclase.
		65. Clay.
		66. Wolfram.
		67. Finely crystalline limestone.
		72. Iron pyrites decomposing.
		73. Mispickel.
		74. Mica schist with small peacock copper crystals (3 specimens).
		75. Graphitic slate.
		76. Anhydrite.
		77. Tetrahedrite.
		80, 37. Fossil wood silicified.
		82. Iron pyrites with tetrahedrite.
		83. Anglesite crystals on limonite.
		84, 36. Augite crystals on decomposed tuff.
		86. Tetrahedrite.
		87. Calcite.

List of Assaye and examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April, 1892—continued.

Substance.	For whom.	Result.
		88. Celestine with sulphur. 89. Haematite with specularite. 90. Chalcedony. 92. Psilomelane. 93. Fossil. Genus *Trigonia.* 94. Cuprite with native copper. 95, 96 and 98. Limonite. 97. Chalybite. 98. Iron pyrites in talcose schist. 99 Andalusite. 100. Ferriferous opal. 101. Chryscolla. 102. Orbicular Diorite—"Corsite." 103(ii). Galena. 104. Talc in quartz. 106. Apophyllite. 107. Antimonite. 108. Chalcedony—"Bloodstone." 109. Native copper. 110. Crystalline limestone. 111. Haematite. 157. Tremolite. 162. Zeolite in cavity of diorite. 180. Felspar—plagioclase. 184. Ditto. Carlsbad twin of orthoclase. 198. Selenite. 199. "Porfido Verdo Antiquo." 222. Tourmaline in quartz. 295. Limonite. 324. Franklinite. 337. Syenite. 347. Galena. 363. Erubescite. 382. Cinnabar. 391. Pyrargyrite with barytes. Some minerals without numbers as follows:— "Ore of antimony"—Valentinite. Specimen of calcite. Specimen of calcite specularite with pyrrhotine. The specimens numbered 10, 17, 39, 41, 50, 86, 112 and 326 have no distinctive characters.
Quartz	Sent by J. P. KIRKUP (on account of T. W. HUGHES), Yellandellapadu, Nizam's State Railway, Hyderabad.	Quantity received 3½lb; contains no gold.
"White clay" for examination.	BURN & Co., Calcutta .	Kaolin.
One specimen of "smelted galena ore."	F. W. HEILGERS & Co., Calcutta.	Assayed for gold, silver and lead.
"Hard black substance" for determination.	J. MACKAY, Moniakhal Tea Estates, Silchar.	Lignite, with iron pyrites.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April 1892—continued.

Substance.	For whom.	Result.
Two specimens of limonite with quartz.	T. W. HUGHES, Geological Survey of India, Mergui.	Both contain gold.
A specimen of lignite for assay.	C. W. HOPE, Dehra Dun, North-Western Provinces.	
Three specimens of coal for assay.	C. MEDLYCOT JONES, Calcutta.	
One specimen of quartz from Kanmoora, Border of Sonthal pargunnahs.	C. HIGGS, Calcutta.	Assayed for gold.
Two specimens of mundic.	OCTAVIUS STEEL & Co., Ld., Calcutta.	Assayed for gold and silver.

Notifications by the Government of India during the months of February, March and April 1892, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion, Reversion and Retirement.

Department.	Number of order and date.	Name of officer.	From	To	Nature of appointment, etc.	With effect from	Remarks.
Revenue and Agricultural Department.	$\frac{370}{9}$ Surveys, dated 16th February 1892.	F. H. Smith	Assistant Superintendent, 3rd grade.	...	Substantive.	11th February 1892.	

Annual Increments to graded Officers sanctioned by the Government of India during February, March and April 1892.

Name of officer.	From	To	With effect from	No. and date of sanction.	Remarks.
T. H. D. LATOUCHE	R 660	R 700	1st April 1892.	Revenue and Agricultural Department, No. $\frac{774}{92}$, Surveys, dated 14th April 1892.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph office.
T. W. H. Hughes	Mergui	Tavoy.
C. L. Griesbach . . .	Almora, Kumaon N. W. P.	Almora.
R. D. Oldham	Calcutta	Calcutta.
P. N Bose	Tavoy	Tavoy.
T. H. D. LaTouche . . .	Lahore	Lahore.
C. S. Middlemiss . . .	Naini Tal	Naini Tal.
W. B. D. Edwards . . .	Murree	Murree.
P. N. Datta	Thayetmyo . . .	Thayetmyo.
F. Noetling	Yenangyoung . . .	Yenangyoung.
Hira Lal	Abbottabad . . .	Abbottabad.
Kishen Singh . . .	Dera Ismail Khan . .	Dera Ismail Khan.

DONATIONS TO THE MUSEUM.

FROM THE 1ST FEBRUARY TO 30TH APRIL 1892.

2 fossils.

PRESENTED BY H. B. W. GARRICK, CALCUTTA.

2 specimens of phosphatic nodules, from Ootatoor, Perambalur taluq, Trichinopoly district.

PRESENTED BY DR. H. WARTH, OFFICIATING SUPERINTENDENT, GOVERNMENT CENTRAL MUSEUM, MADRAS.

Specimens of Gwalior clay.

PRESENTED BY COL. PITCHER, DEPT. LAND RECORDS, GWALIOR STATE.

4 fossils.

PRESENTED BY RAGONATH RAO, YADOW BHAGVAT, SECRETARY, COUNCIL OF REGENCY, GWALIOR STATE.

1 specimen of muscovite, from Hazaribagh district.

PRESENTED BY EDWIN T. HOLLINGSWORTH.

ADDITIONS TO THE LIBRARY.

FROM 1ST JANUARY TO 31ST MARCH 1892.

Titles of Books. *Donors.*

BEYRICH, *E.*—Uber Einige Cephalopoden aus dem Muschelkalk der Alpen und Uber Verwandte Arten. 4° Berlin, 1867. R. D. OLDHAM, ESQ.

BRONN'S Klassen und Ordnungen des Thier—Reichs. Band II, Abth. III, lief 13 to 16. 8° Leipzig, 1892.

BURNIE, *R. W.*—Memoir and letters of Sidney Gilchrist Thomas. 8° London, 1891.

CARPENTER, *Will. B.*—The Microscope and its revelations. 7th edition. 8° London, 1891.

COTTEAU, PERON, and GAUTHIER.—Échinides Fossiles de L'Algérie. Fasc. 10. 8° Paris, 1891.

EISSLER, *M.*—The Metallurgy of Silver. A practical treatise on the amalgamation, roasting, etc., of silver ores, including the assaying, melting, and refining of silver bullion. 8° London, 1891.

FRANKLAND, *Ed.*, and JAPP, *F. R.*—Inorganic Chemistry. 8° London, 1884.

HÖHNEL, *L. R.*, ROSIWAL, *A.*, TOULA, *F.*, und SUESS, *E.*—Beiträge zur Geologischen Kenntniss des Östlichen Afrika. 4° Wien, 1891.

THE AUTHORS.

JOHN, *Robinson.*—Our Trees; a popular account of the trees in the Streets and Gardens of Salem, Essex, County Mass. 8° Salem, 1891.

THE ESSEX INSTITUTE.

JUPTNER, *Baron Hanns.*—Traité Pratique de Chimie Métallurgique. 8° Paris, 1891.

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KLIPSTEIN, *Dr. A. v.*, and KAUP, *Dr. J. J.*—Beschreibung und Abbildungen von dem in Rheinhessen aufgefundenen Colossalen Schedel des Dinotherü Gigantei mit geognostischen Mittheilungen über die knochenfuhrenden Bildungen des mittelrheinischen Tertiärbeckens; and Atlas. 4° P. and Fol. Darmstadt, 1836 and 1843. R. D. OLDHAM, ESQ.

MEDLICOTT, *H. B.*—The Evolution of Mind in Man. 8° P., London, 1891. THE AUTHOR.

MENDELIEFF, *D.*—The Principles of Chemistry. Vols. I and II. 8° London, 1891.

MURRAY, *J.*—Hand-book for travellers in Devonshire. 8° London, 1892.

MURRAY, *J. A. H.*—New English Dictionary on historical principles. Part VI, CLO - CONSIGNOR. 4° Oxford, 1891.

Paléontologie Française, 1re séri, Animaux Invertebrés. Terrain Tertiaires, Éocene Echinides, Livr. 24-25; and Terrain Jurrassique, Gastropodes, Livr. 90. 8° Paris, 1891-1892

PHILLIPS, *H. J.*—Engineering Chemistry. 8° London, 1891.

PHILLIPS, *J. A.*—Elements of Metallurgy. A practical treatise on the art of extracting metals from their ores. 3rd edition. 8° London, 1891.

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Mining Journal. Vol. LX, Nos. 2884-2885, and LXI, No. 2937, to LXII, No. 2950. Fol., London, 1891-1892.

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" Memoir on the Indian Surveys, 1875-1890. By Charles E. D. Black. 8° London, 1891. REVENUE AND AGRICULTURAL DEPARTMENT.

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„ Johns Hopkins University Circulars. Vol. XI, Nos. 92—95. 4° Baltimore, 1891-1892. JOHNS HOPKINS UNIVERSITY.

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„ Memoires couronnés et autres mémoires publiés par l'Académie Royale des Sciences. Tome XLIII-XLV. 8° Bruxelles, 1889 and 1891. ROYAL ACADEMY OF SCIENCE, BELGIUM.

„ Mémoires couronnés et mémoires des savants étrangers publiés par l'Académie Royale des Sciences. Tome L-LI. 4° Bruxelles, 1889-1890. ROYAL ACADEMY OF SCIENCE, BELGIUM.

BUDAPEST.—Erläuterungen zur Geologischen specialkarte der Länder der Ung. Krone. Blatt $\frac{\textit{Zone } 19.}{\textit{Col. } xxix.}$ (1 : 75,000). 8° Budapest, 1890. HUNGARIAN GEOLOGICAL INSTITUTE.

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„ Jahresbericht der Kgl. Ung. Geologischen Anstalt; für 1889. 8° Budapest, 1890. HUNGARIAN GEOLOGICAL INSTITUTE.

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DEHRA DUN.—Synopsis of the results of the operations of the Great Trigonometrical Survey of India. Vols. XXIII and XXIV. 4° Dehra Dun, 1891. GREAT TRIGONOMETRICAL SURVEY OF INDIA.

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LONDON.—Journal of the Society of Arts. Vol. XL, Nos. 2037—2051. 8° London, 1891-1892. THE SOCIETY.

„ Mineral Statistics of the United Kingdom of Great Britain and Ireland with the Isle of Man, 1890. Flsc., London, 1891. SECRETARY OF STATE.

„ Proceedings of the Royal Geographical Society. New series. Vol. XIII, Nos. 10—12. 8° London, 1891. THE SOCIETY.

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„ Bulletin de la Société Géologique de France. 3me série, Tome XIX, No. 7. 8° Paris, 1891. THE SOCIETY.

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„ Sitzungs berichte der Kais. Akad. der Wissenschaften.
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„ XLI, heft. 1. 8° Wien, 1891. THE INSTITUTE.

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UNITED STATES MINT.

„ Smithsonian Contributions to Knowledge. Experiments in Aerodynamics, by S. P. Langley. 4° Washington, 1891.
THE SMITHSONIAN INSTITUTION.

„ Smithsonian Miscellaneous Collections. Vol. XXXIV, Lecture IX. Mental overwork and premature disease among Public and Professional men, by C. K. Mills. Index to the Literature of Columbium, 1801-1887. By F. W. Traphagan. Bibliography of the Chemical Influence of Light. By Alfred Tuckerman. 8° Washington, 1885, 1886 and 1891. THE SMITHSONIAN INSTITUTION.

„ U. S. Department of Agriculture. North American Fauna. No. 5. 8° Washington, 1891. U. S. DEPARTMENT OF AGRICULTURE.

MAPS.

PARIS.—Carte Géologique détaillée de la France. Sheets 152 and 236. Map. Paris, 1891. GEOLOGICAL SURVEY OF FRANCE.

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G. I. C. P. O.—No. 1 D. G. Survey.—9-6-92.—630.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1892. [August.

Note on the Locality *of* Indian Tscheffkinite, *by* F. R. MALLET, *late Superintendent, Geological Survey of India.*

The rare and interesting mineral, from Southern India, subsequently identified as tscheffkinite, was obtained by M. Leschenault de la Tour in 1817 or 1818, during his travels for the Muséum d'histoire naturelle at Paris. Occupied mainly in botanical and zoological pursuits, M. Leschenault appears to have been able to give but a secondary place to geology and mineralogy, and some, at least, of the minerals he obtained were identified, not by himself in the field, but by others in the laboratory many years later. Amongst these were the tscheffkinite specimens, the nature of which, indeed, could not have been ascertained without analysis, as the mineral was, previous to the examination of Leschenault's specimens, entirely unknown. Its outward appearance is not strikingly suggestive of any peculiar interest, and hence, perhaps, the fact that in the account of his journey[1] there is no allusion of any kind to the substance in question, and, consequently, no direct indication of the locality where it was found. But it seems at least equally, if not more, likely that this omission is due to M. Leschenault having not obtained the specimens himself *in situ*, but been given them by M. Healt (*sic*),[2] concerning whom he writes[3]—" My mineralogical collection has been principally enriched by the gifts of M. Healt, adjunct and brother-in-law of M. Carpenter, commercial

[1] Rélation d'un voyage à Karikal et à Salem; *Mémoires du Muséum d'histoire naturelle*, t. VI (1820), p. 329.

[2] Is this the Mr. Heath who, some years later, was connected with the Porto Novo Iron works, and who has left an account of the Salem ores which were smelted there?

[3] *Op. cit.*, p. 344.

resident" (at Salem). "He collects everything of mineralogical interest that is obtainable in the country, and he has had the goodness to give me many specimens of corundum, the ore of native iron,[1] garnets," etc.

The substance was first analysed by Langier in 1825, who calls it merely "un minéral noir de la côte de Coromandel."[2] This extremely vague, and, as it now appears, incorrect, locality has since then been assigned to it by mineralogical authors generally. The rarity of the mineral, which seems to have been found in only three places,—Southern India, the Urals, and Virginia—in none of which more than a few specimens have been obtained, makes it desirable that the spot in India where it occurs should be accurately known; the more so as very few indeed of Leschenault's specimens of it are now forthcoming. I have been lately informed by M. A. Lacroix that none are to be found in any of the public collections of Paris. There is, however, a small piece in the British Museum at South Kensington, with a written label underneath it, which I copied some years ago, and which runs as follows:—" Minéral brun de Coromandel (Beudant, p. 652).—Fragment du morceau rapporté par Leschenault et analysé par Langier, *Loc.*, Kantamala, Côte de Coromandel, parait être une vraie Tscheffkinite d'après la nouvelle analyse encore inachevée de M. Damour (Juillet, 1861)."[3] When writing Part IV of the Manual of the Geology of India, in Calcutta, I was unable to trace the position of Kantamala. I had not access then to Leschenault's original memoir, which now lies before me. It does not contain very much geological information, and, as previously remarked does not allude to anything resembling tscheffkinite. But on page 344 there is the following passage:—"At about two leagues[4] to the south-south-west of Salem, in the mountain of Kantiamalé, there is a sandy iron-ore that is collected in the ravines. It is very rich. The iron that is smelted from it produces an excellent steel."[5]

I do not think anyone conversant with the latitude that obtains in the spelling of Indian names, and specially in those of Southern India, will feel much doubt that 'Kantamala' of the British Museum label, and 'Kantiamalé,' are the same. It is true that 'Kantiamalé' is not on the Coromandel coast, but in the Salem district. But exactly the same mistake was made by Count de Bournon in relation to Leschenault's specimens of indianite, which he described as from Salem "on the coast of Coromandel."[6] Nor is the mistake confined to indianite, for M. Lacroix notices that "the rocks and minerals included in de Bournon's collection are labelled as coming from Salem 'on the Coromandel coast,' although Salem is over 100 miles from the sea."[7] Whether the error originated with him, or was merely accepted by him on the authority of some one else, is not clear; but it is

[1] That is to say, the ore used in the native smelting furnaces.

[2] *Mém. du Muséum d'hist. nat.*, t. XII (1825), p. 189.

[3] The label is on a form with the name of M. Saemann printed at the top. The specimen, therefore, appears to have come from his collection, and, presumably, was in that of M. Cordier still earlier.—See footnote, p. 125.

[4] Say about 5 miles:

1 old French posting-league = 2·42 Eng. miles.
1 " league of 25 to 1 degree = 2·76 Eng. miles.

[5] There follows a short outline of the native method of steel-making, but, as it does not differ from that given in much more detail by other writers, it is not worth quoting here.

[6] Observations sur quelquesuns des minéraux, soit de Ile de Ceylan, soit de la Côte de Coromandel, 1823.

[7] *Bulletin de la Société Française de Minéralogie*, t. XII, p. 282.

not likely to have been made by Leschenault himself, who was familiar with the district.[1]

It only remains, then, to identify the 'mountain of Kantiamalé.' I have carefully examined sheets 61 and 79 of the Indian Atlas (1 inch = 4 miles), and the Revenue Survey map of Salem taluq (1 inch = 1 mile), within a radius of 8 or 10 miles round Salem, without finding the name in question, the only names at all like it are, Keddamalai hill (spelt Keddmally on atlas sheet), 10 miles south-east from Salem, and Kanjamalai hill (Kunjamullay of atlas sheet), the culminating peak of which (3,238 feet) is 7 miles, and the eastern end of the principal ridge 5 miles, west-south-west from Salem. Kanjamalai hill[2] is composed of metamorphic rocks, which form a great synclinal and include three splendid beds of magnetic iron-ore, the ore has been worked by the natives from time immemorial, a portion of the iron produced being converted into wootz steel. This is, I think beyond all reasonable doubt, the mountain containing rich iron-ore referred to by M. Leschenault. The terminations *malé* and *malai* (meaning *mountain*) are evidently the same, and in the rest of the words (Kantia and Kanja) there is a difference of but one important letter—a difference which may easily have arisen from M. Leschenault having failed to catch the correct pronunciation, or through some clerical error.[3] There is also a difference in bearing, Kantiamalé, being described as about 5 miles south-south-west from Salem, while Kanjamalai is the same distance west-south-west. I do not think this is of much importance, however, considering how frequently errors in bearing creep in.[4]

There are some small unnamed hills marked on the maps in the exact position mentioned by Leschenault, and it might be surmised that one of these is Kantiamalée. But, besides the fact that he speaks of a *mountain*, if there were important deposits of iron-ore in the two adjacent positions, it is unlikely that Leschenault would have ignored the celebrated ones of Kanjamalai, and highly improbable that Messrs. King and Foote would have ignored those at Kantiamalé.

Kanjamalai hill being within 5 miles of Mr. Healt's residence, was doubtless very thoroughly explored by him, and it seems most probable that he found the tscheffkinite there, and gave specimens of it to M. Leschenault, who may have derived his information about the hill from the same source.

If the above conclusion as to the spot where such an interesting mineral occurs be accepted, it is to be hoped that an attempt will be made to re-discover it, and learn something as to its mode of occurrence.

It may perhaps be worth remark here that Langier's analysis, which, as it

[1] Leschenault's collection was in the Muséum d'histoire naturelle at the time Langier's analysis was made, but one or more specimens of tscheffkinite seem to have been also in the possession of M. Cordier (Professor of Geology in the Museum, as Langier was Chemist), from whom they passed to M. Saemann, who gave Damour the piece analysed by him. It seems probable that some, at least, of the tscheffkinite passed through de Bournon's hands at the time he examined Leschenault's specimens of indianite, corundum, etc.

[2] A detailed description of which is given by Messrs. King and Foote in the Memoirs of the Survey, vol. iv, p. 379.

[3] An analogous case, where "I" has been supplanted by "S," might be adduced in the error by which, during 40 years, the so-called mineral Jyepoorite figured as Syepoorite (*vide* vol. xiv, p. 192).

[4] *e.g.*, Ganypittah is described by Dr. Heyne as west of Ongole, instead of south-west, (vol. xii, p. 168).

appears in mineralogical text-books, is copied from Beudant's *Traité de Minéralogie*, 2nd edition (1832), is incorrectly given in that work. It stands in the original memoir[1] as follows:—

Oxide of cerium	36·5
Oxide of iron	19·8
Silica	19
Lime	8
Alumina	6
Water	11·05
Oxide of manganese	1·20
Oxide of titanium	8
	109·38 (*sic*)

The excess, M. Langier adds, is due to the cerium and iron having been weighed as peroxides, while they exist in the mineral as protoxides. Their percentages should therefore be diminished to 31·1 and 15·4 respectively, the total being thus reduced to 99·25 (*sic*).

Comparatively recently tscheffkinite has been found in Nelson Co., Virginia, and analysed by R. C. Price.[2] In discussing the results he says:—"When considering the cerium earths as protoxides, tscheffkinite was classified by Dana as a subsilicate with titanic oxide basic; the oxygen ratio for $SiO_2 : TiO_2 : R_2O_3 : RO = 5 : 4 : 2 : 4$. With these earths and sesquioxides, the above must be rejected; and in order to consider the published analyses of tscheffkinite (1) and (4), I have assumed the cerium earths to exist in the same proportions as have been found in the present specimen,[3] which affords oxygen ratios for them as follows:—

	SiO_2	TiO_2	R_2O_3	RO
"(1) Ilmen	77	55	44	25
(4) Coromandel	77	64	44	24
Nelson Co.	78	62	40	28

"From the inspection of these figures it appears highly probable that the titanic oxide should be regarded as replacing silica. The composition of the Nelson Co. mineral approximates to—

"$2\,(Ca, Be, Fe, Mg)\,O, (Ce, Di, La, Fe)_2\,O_3.\ 5\,(Si, Ti)O_2$

and the formula of each of the above will fairly correspond to a bisilicate of the amphibole group, with silicon replaced by titanium."

Another analysis of Virginia tscheffkinite (from Bedford Co.) has been made by L. G. Eakins,[4] who remarks that "the molecular ratios seem to lead to no definite or satisfactory formula—a result quite in accordance with the evidence furnished by the microscopical examination of sections." Microscopic examination showed the

[1] *Op. cit.*, p. 194.
[2] *American Chemical Journal*, vol. x (1888), p. 38.
[3] Damour thought that didymium and lanthanum were present, together with the cerium, in the Indian tscheffkinite (Dana's System of Mineralogy, p. 388).
[4] *Amer. Jour. Sci.*, vol. xlii (1891), p. 36.

transparent, amorphous, apparently original, material to have partially decomposed into an opaque ochreous matter, besides which there were bands of various secondary minerals visible. A sample of Price's tscheffkinite showed an almost identical structure under the microscope. Mr. Eakins therefore concludes that tscheffkinite is not a true mineral, but only a mixture. A somewhat similar opinion seems to have been held by Des Cloizeaux about the Indian tscheffkinite, in respect to which he writes[1]—"The material is not perfectly homogeneous, for I have observed with the microscope that it is composed of a brown mass, without any action on polarised light, in which are included very small, colourless, strongly birefringent grains."

Geological Sketch *of the* country north of Bhamo, *by* C. L. GRIESBACH, C. I. E., *Superintendent, Geological Survey of India.*

Geology.

East and north-east of Bhamo a series of hill ranges, all more or less parallel to each other, forms a compact mountain system, which has been traced to far north of the Maikha branch of the Irrawaddi by Major Hobday and others, and which in some way, not known to us exactly, is most probably linked to the north-eastern extension of the Himalayan system. It forms the natural frontier between Burma and China, but not the *watershed* between the former country and Yunnan, which has not been explored yet. This system of ranges rises to considerable heights (8,000 to 9,000 feet) and possesses an average direction of strike from south to north and north-east, a direction which coincides as I have ascertained with the general direction of the strike of the strata forming these ranges.

The mountain system is crossed by several transverse valleys; as, for instance, the Maikhâ branch of the Irrawaddi, the Taiping, etc.

As far as it was possible to discover during the very rapid traverses made by Dr. Noetling and myself, it appears that the entire area north of Bhamo is formed by a succession of flexures of older rocks, all striking more or less north and south and north-east to south-west, which flexures have been extensively eroded by the Upper Irrawaddi drainage.

Several larger synclinal troughs, or rather areas of depression, have been formed when the beds composing the country north of Bhamo were compressed into folds; such, for instance, is probably the area of the Indawgyi lake basin and also the broad valley of the Irrawaddi between Hokat and Watu.

The principal formations found in the Northern Bhamo district are the following:—

1. Metamorphic, including probably the palæozoic group.
2. Mesozoic strata.
3. Tertiary beds.
4. Igneous rocks.

It has been ascertained that by far the greatest part of the ground explored by

[1] Manuel de Minéralogie, t. i, p. 554.

Metamorphic rocks.

us during the last field season is formed of crystalline (metamorphic) rocks; amongst which a coarse, porphyritic gneiss is very characteristic in the eastern part of the area reported on, and it was also met with by Dr. Noetling in the Mogaung area.

Besides the gneissic rocks, there are also schistose rocks, phyllites and hornblendic rocks.

The whole group of metamorphic rocks has evidently undergone most extensive folding and crumpling, with subsequent erosion; but it is now so extensively obscured by sub-recent deposits and vast forests, that it will, for a long time to come, be next to impossible to arrive at any closer knowledge of the sequence of the series.

Palæozoics.

But it appears probable that certain more or less crystalline rocks, chiefly limestones, which occur in the midst of the metamorphic flexures, and seemingly conformably to the latter, belong to the palæozoic groups and are possibly silurian, though actual proofs are wanting.

Mesozoic strata.

The only trace of mesozoic rocks consists in a pebble, containing an ammonite found by Dr. Noetling near the amber-mines. It is probably cretaceous and may have been derived from a tertiary conglomerate within the amber-mines formation.

Tertiary formation.

Patches of sandstone, mostly highly disturbed, occur here and there, probably forming remnants only of a once much more extensive series of tertiary beds. Such are found in the Indawgyi lake district, west of Mogaung, in the Amber Mines district and in patches north of the "Confluence."

These patches of tertiary formations may include members of several divisions of the system, but resemble mostly the miocene sandstone series of Upper Burma, and like the latter are characterised by the occurrence of patchy seams of poor lignitic coal.

The amber-mines (on which Dr. Noetling reports in detail) are situated within the area of tertiary deposits.

Younger tertiaries, including recent deposits.

Widespread alluvial deposits, both fluviatile and lacustrine, occupy the wide troughs of the Irrawaddi and its minor confluents. From an economic point of view, perhaps the most important of these deposits is the widespread formation of clays, gravels, and sands filling the open trough through which the Irrawaddi flows between Watu and Hokat, and which is some 20 to 24 miles in width. This trough is partly filled by almost horizontally bedded deposits of clays and gravels chiefly, which are possibly of lacustrine origin, though merging upwards into deposits of fluviatile nature.

The formation is of some economic importance, as it contains a not inconsiderable amount of gold disseminated throughout it in fine dust, to which reference is made below.

Igneous rocks.

Parallel with the general strike of the lines of disturbance of the older rocks appear long strips of igneous rocks, which I believe have been intruded in fissures of dislocation.

They are accompanied by numerous dykes and intrusions in the neighbouring rock-formations; and there is some economic interest attached toem, in as much as the mineral known in Burma as jade occurs in veins within these igneous intrusions, which, as far as I know, are all of basic rocks.

Broadly speaking, three principal lines of intrusion are found within the area here reported on, namely—

One, running almost due north and south along the 97° 30′ longitude to near the confluence: another forming the valley of the Irrawaddi, in the defile between Bhamo and Sinbo, and continued northwards along its right banks; the third belongs to the Jade Mines district.

B.—Economic Notes on the Upper Irrawaddi valley north of Bhamo.

Having briefly sketched the geological features of the hill ranges which bound the Irrawaddi river valley north-east of Bhamo and form our frontier with China, I may at once state that they are practically barren of all useful minerals. There are reports that lead ores occur, but I have not come across any during my journeys in these hills; and if they ever existed, they would be practically valueless.

The only minerals remaining to be noticed are the following:—

Coal.

The only traces of coal which occur within the area described here are found some 10 miles west of Mogaung, as noticed by Dr. Noetling; but they appear to be of little, if any, value.

Occasionally small quantities of coal (lignite) are brought to Myitkyina for sale. This mineral comes from the neighbourhood of Talang, north of the Pungin Kha, about 16 miles north-north-west of the confluence. From inquiries which I made of natives of that country, there is a seam of this coal there some 2 to 3 feet in thickness, which in any case would scarcely be good enough to work, and with wages as high as they are in those parts at present, is altogether valueless.

The Kachins sell this lignite at 8 annas a basket at Myitkyina, and it need scarcely be said that it would be cheaper to import English coal at this rate.

It was reported that coal was found between Ningrong and Kantaoyaung, some 24 miles due east of Ayainuama on the Irrawaddi, of which supposed coal specimens were forwarded to me. This proved to be not coal at all, but hornblendic rock.

Gold.

This metal is found in the form of fine grains and leaflets in the recent deposits of Irrawaddi valley and of all its tributaries.

Its presence is known to the natives, who wash these deposits after a fashion, and make thereby from about 4 to 12 annas per day a man. Their mode of washing for it is by means of wooden cradles, rarely more than 5 feet long by 2 feet wide. The natives are fairly efficient at this work, and would no doubt easily acquire a more modern mode of winning the precious metal, if put in the way of it. But nowhere have I noticed that they dig deep into the recent or sub-recent deposits for auriferous sands, although such must exist in lower depths most certainly. They usually collect only the most recent accumulations of sands and grit which are caught on the upper reaches of sandbanks in the river. That in such situations gold exists, and as I have seen myself, in well rounded, water-worn leaflets of minute size, proves that probably the river is even now cutting through an alluvial deposit which contains gold, and that the latter is re-deposited after floods on the sandbanks and projecting spits of land along the banks. It seems highly probable that within the thickness of the sub-recent gravels and clays of the Upper Irrawaddi a horizon may be found in which gold is more plentiful and which might pay if regularly mined for on a larger scale. Even as it is, the surface sands along

the banks contain probably not less than 30 grains of gold per ton of dirt, which would be good enough to pay working on a larger scale.

The only place where I saw natives digging deeper into the auriferous deposits was about 2 miles north of Myothit, north-east of Bhamo, where they have dug a trench several feet deep and some 40 to 50 feet long into much decomposed gneissic strata, which they wash for gold. The presence of gold in this rock must be in very finely disseminated form; and I have satisfied myself that in the last-mentioned locality there is no auriferous lode or reef, but that the gold occurs in the gneiss itself in very minute quantities. I have not seen nor even heard of any locality where gold occurred in reefs.

Spinel; rubies.

Major Hobday of the Survey of India reported the discovery by him of numerous crystals of spinel in the recent deposits near the junction of the Pungin Kha and Mali Kha, north of the confluence.

I myself have met with very minute fragments of such crystals in the sands and recent alluvium of the Irrawaddi below Myitkyina, where the heavy iron-sand which is left in the cradles along with the gold flakes when washing the sands for the latter, is often largely mixed with the fine splinters of spinel crystals. These increase in number and size higher up the Irrawaddi; and at Watu I have found large crystals of the same with millions of small fragments of the same; amongst them splinters which appear to me to be rubies, but are too small for certain determination. It is therefore certain that somewhere higher up the river, rock must be *in situ* which contains these minerals. The deposits near the Pungin Kha contain these crystals in the same manner as the alluvial gravels near Watu, and I have no doubt that they are derived from some metamorphic rock (perhaps crystalline limestone) still further north. It is a question well worth inquiring into, but this cannot be done until the country is much more accessible than it is now.

From the foregoing it appears, therefore, that there are widely extended alluvial deposits in the Upper Irrawaddi valley, which are already known to contain gold, spinel, and possibly also rubies. By far the greater part of the area which is formed by these alluvial deposits is practically a desert, as very few, if any, settlements exist there, and thus the country may be looked upon as a particularly favourable field of enterprise for mining purposes, if the labour difficulties could be overcome.

Preliminary Report *on the* economic resources *of the* Amber *and* Jade mines area *in* Upper Burma, *by* FRITZ NOETLING, PH.D., *Palæontologist, Geological Survey of India.*

Situation of the mines.

Amber.

The amber-mines which were examined by me are situated about 5 miles to the south-west of the village of Maingkhwan on a low isolated hill, which rises abruptly from the surrounding plains. There is no doubt that this hill, which has an elongated shape, the main axis running N.E.-S.W., formed part of a formerly wider extended river terrace, which has, however, been considerably denuded and worn away during the process of time. It is therefore *a priori* not improbable that amber may be

found also at other localities in that part of the country near the Nangotiemaw hill. I was subsequently informed that the amber-mines proper—that is to say, those which at present produce the amber—are situated west of, and are close to, a village called Lalaung.

Geology.

The strata in which the amber is found belong to the tertiary formation, probably to the lower miocene. The exact age cannot be stated yet, as no fossils have so far been discovered. The amber-bearing beds consist of a soft, blue clay, which is superficially discoloured brown, the discolouring being apparently due to the disintegrating action of organic acids formed by the extremely rich vegetation; and it may therefore be expected that the brown portion of clay forms only a thin covering of varying thickness on the exposed parts of the blue clay. It might further be anticipated that the amber found in this clay, being also under the influence of the chemical process which discoloured the clay, would be of inferior quality to that which is extracted from the blue clay. The experimental shafts sunk by me have proved that both these views are correct.

The clay is well stratified, and it reminds me very much of the blue, coal-bearing clay of the Chindwin coal-fields. The strike is N.W.-S.E. with a dip of 80° towards west. It was impossible to ascertain whether amber is found all throughout this clay, but I rather doubt it. If we may judge from the extension of the old pits, which are chiefly on the top and the western slope of the hill, the amber is limited to the upper part of the blue clay. This view being correct, the amber would be found in a bed of highly inclined strata forming a broad band along the western side of the Nangotiemaw hill running in N.W.-S.E. direction. The continuation of the bed to the south will strike the supposed amber-mines at Lalaung.

The occurrence of amber.

It may be well to keep in mind that amber is nothing but a kind of resin which has been produced in exactly the same way as resin is produced by the trees now-a-days, only that the amber-producing trees—pine trees very probably—were extremely rich in resin, and that the process of production went on during tertiary times. The hardened resin accumulating in the amber-pine forest during the course of centuries was gradually washed away by the rains, and being of low specific gravity, easily floated down in the rivers to the sea, which then covered the whole of Upper Burma, where it was again deposited here and there. The amber deposits were covered with clay, the deposit of the sea, and this process may have been going on for a long period till the amber-bearing strata, as they present themselves in their present thickness of not less than 600 feet, had been formed.

It is therefore easily understood that the amber will be found in isolated pockets of smaller or greater extension and thickness, but once one of these pockets is exhausted the miner will have to look for another one, which may not be indicated by superficial signs. The native style of extracting the amber, to which I shall refer presently, must therefore be a highly speculative undertaking, as it merely depends on luck whether the workmen will strike an amber-bearing pocket or not.

The amber: its colour and value.

The amber is found in lumps of various sizes up to the size of a man's head; these are either rounded or more frequently flattened, having exactly the same shape as the pebbles on a beach, thus proving that they have undergone a considerable amount of wear and tear before they were deposited.

The colour of the amber varies from light yellow to dark brown, in all shades and various degrees of transparency, the most common colour being a dark reddish-brown, which may very well be compared with the colour of dark Madeira wine. Specimens of this kind are nearly always flawed, and contain streaks of minute fragments of wood. Transparent pieces are of a more reddish colour. The colour most valued by the natives is honey-yellow; larger pieces of this kind are rare. The milky-white, cloudy coloured variety, such as is at present particularly appreciated in Europe, does not occur in the Burma amber.

The Burmese amber is further more distinguished by one peculiarity which would lower its value in the European market; this is its fluorescence. This is the bluish tinge which appears when looked at under a certain angle, which is sometimes so strong that fine yellow pieces appear of an ugly greenish colour.

Mining for amber.

The amber is extracted in the most primitive fashion. No surface indications reveal the presence of a pocket of amber; the selection of a spot where mining operations are going to be started is perfectly accidental. Having selected a spot, a man digs a square hole of about $1\frac{1}{2}$ feet by 2 feet by means of a rude tool, which resembles the Burmese taywin, that is to say, a short chisel-shaped iron affixed to a heavy wooden club-shaped handle. With this instrument the soft clay is loosened, and by means of a rough wooden shovel thrown into a bamboo basket, (both made on the spot) and hauled up by means of a long bamboo. In this way the miner digs himself gradually into the clay, constructing a chimney-like pit which just affords room enough for one man to work in. If an amber-bearing pocket is reached, which may be found at any depth, it is worked, and if of some extension, other pits are sunk around the original one until all the amber is extracted by working from one pit to the adjoining ones. As it happens frequently enough, no amber is found; then the pit is abandoned and another spot selected. It is perfectly clear that under this system of extraction the output solely depends on luck; one man may find a large quantity, while another works for weeks without getting more than a few pieces.

My experiments.

I was of course obliged to accept the native method, but all I can say is that I was extremely unsuccessful. Although I sunk about six shafts, which I worked with sometimes nine coolies at a time for nearly a fortnight, the whole output consisted of a few small pieces of disintegrated amber worth nothing. This may not be very encouraging, but in my opinion it is absolutely no sure test as to the value of the amber-mines; experiments to this effect must be carried out on a larger and more systematic scale and over a longer period.

Value of the mines.

Although I have no doubt that amber is found in large quantity either at Lalaung or elsewhere, it may safely be said that it will never form an article of export to Europe unless the fashion changes. The two qualities which are against it finding a market at home are, first, its colour; second, is fluorescence.

As regards the colour, only the milky white clouded pieces of amber command at present a considerable value in the European market; all the other colours, yellow and red, in their various degrees of transparency, are of inferior value, and would hardly be appreciated in Europe. Burmese amber would therefore range in the second place as long as the fashion does not change, and it is still more lessened

in its intrinsic value by the fluorescence which is never found in European amber. Only amber from Sicily shows the same peculiarity, and although found in some quantity, it is for this very reason practically unsaleable.

There is another reason why the fluorescence will be fatal to the Burmese amber. Up to only a very recent date the firm of Messrs. Hantien and Beeker in Königsberg, who are owning the monopoly of the Prussian amber-mines, which are the chief amber-producers, had every year an enormous quantity of refuse amber which could hardly be disposed of; the only way of utilising it being the manufacture of varnish, and as there is only a limited demand for such varnish, large quantities of the refuse were every year stored away. Some years ago the problem of smelting the amber was solved; the process consisting in softening the amber by steam under high pressure and then compressing the mass by hydraulic pressure. The amber thus produced resembled in colour the yellow or brown variety, its only difference from the natural pieces being its fluorescence. The firm, stopped the manufacture of this artificial amber because large pieces of it could be produced at such a low cost price that if thrown on the market it would have soon cut out the inferior qualities of natural amber altogether. The firm, rather than be its own competitor, stopped the manufacture of smelting the refuse altogether, and the storage of the latter is still going on. There is, however, no doubt that the very moment the Burmese amber, which in its physcal qualities is similar to the amber produced by smelting the refuse of European amber, would appear on the market as a serious competitor to European amber, the firm would at once take up the manufacture of artificial amber.

It may therefore be foretold with every certainty that if any company which might in the future exploit the amber-mines were not satisfied with supplying the local and China market only, but were to begin to export to Europe, it would find great difficulty in competing against German production; and it may even be doubted whether it would succeed in doing so, owing to the undoubtedly inferior quality of the Burmese amber. But whether the local demand, which may be estimated at about 2,000 viss per year at the outside, will be sufficient to pay a European company remains still to be seen.[1]

In conclusion, I would recommend that experiments on a larger scale should be carried out either at Lalaung or elsewhere with a view to ascertain whether there exists a sufficient quantity of amber to pay a more systematic mode of working.

Note on the Mogaung coal-field.

The so-called Mogaung coal-field might be more properly called Saungka coal-field, the outcrops of the seams being situated along the bank of a small stream of this name. The Saungka chaung is a feeder of the Mogaung stream, which it joins about 16 miles above Mogaung, running down from the hills on the right bank of the river. The coal seams are said to be found about 5 miles to the west of the banks of the Mogaung river. Although I did not visit the locality itself, I may venture a few remarks as to its probable value because I examined the country on both sides of the hills which contain the coal. There is no doubt that the coal is of tertiary age; the hills to the east consist, however, of metamorphic rocks, while those to the west consist of

[1] Dr. Noetling lays perhaps too much stress on the unfavourable appreciation which Burma amber may obtain in the European market. Its great area of sale is in the East, where it will probably hold its own against the European product.—*Ed.*

crystalline limestone, which probably sweeps round the northern side of the tertiary sandstones. To the south the latter are covered up by the alluvial plains of Mogaung. We can therefore safely say whatever may be the thickness of the seams, their extension is very limited, and it is further highly probable that the strata are very much disturbed.

Preliminary report on the Jade-mines. Situation of mines.

Two different groups of mines may be distinguished, which we may call the pit and quarry mines, respectively. The pit mines are situated along the bank of the Uru river, beginning at about Sankha village and extending for a distance of about 40 miles further down. The quarry mines near Tammaw village are situated about 8 miles to the west of Sankha village on the top of a plateau rising to about 1,600 feet above the level of the Uru river.

Geology.

Although it is quite probable the mineral which is commonly called jade and which forms the object of an extensive industry in the Mogaung sub-division is different from the jade proper, I may be allowed to use the old name till chemical and microscopical analysis will have revealed the true nature of this mineral. The Tammaw mines afford the best opportunity for the study of the geological condition under which the jade is found. It here forms a vein of considerable thickness in an igneous rock of blackish green colour. The jade is a purely white crypto-crystalline mineral much resembling the finest marble, containing here and there green specks of various sizes, which form the jade proper. The jade vein is separated from the black rock by a band of a soft and highly decomposed argillaceous mineral. The strike of the vein is approximately north to south, and the dip at about an angle of 20°, varying considerably towards east.

It is difficult to determine the age of these igneous rocks. Before Sankha is reached a similar rock may be seen breaking through tertiary sandstones, but unfortunately the relations of the Tammaw trap to the surrounding strata cannot be observed owing to the denseness of the jungle.

The jade extracted from the pit-mines is found in the shape of boulders, which are undoubtedly derived from localities hitherto unknown, in the neighbourhood of the Uru river. It is probable that this kind of jade, which has undergone a considerable amount of wearings much harder, and therefore of better quality, than the jade extracted from the quarry mines, which has hitherto only laid open the outcrop of the vein; but there is no doubt that once the mining operations have reached a greater depth, where the jade has no longer been subjected to the superficial disintegration, a material will be found which, if not better, will at least be equal to the jade extracted from the pit-mines.

Mining operations.

There are at least 500 men engaged every season in working the quarry-mines at Tammaw. The mining operations are carried on in the rudest fashion. No blasting powder being available, the rock is heated by large fires, and having again cooled down, is broken into pieces by means of enormous iron hammers.

The operation in the pit-mines are less difficult as the alluvial gravel in which the jade boulders are found does not require the tedious process of heating the rock. The miner simply digs a pit and selects the boulders from the stuff dug out of the pit; good pieces of jade are sometimes found in the laterite, which

forms beds of varying thickness along the Uru. These pieces have superficially undergone a certain discolouring in such a way that the original green or white is changed under the influence of the hydrated oxide of iron into a dark red colour. Specimens of this kind are generally known as "red jade."

Value of the mines.

There is no doubt that the jade-mines, especially the jade vein of Tammaw, forms a most valuable property; and there is further no doubt that, besides the Tammaw jade vein, others will be discovered sooner or later, as we know now that jade is intimately associated with a dark igneous rock (trap). As the country abounds in rocks of this kind, it may fairly be expected that a closer examination of these rocks, perhaps some extensive prospecting operation, will result in the discovery of other jade-mines.

Preliminary Report *on the* Iron-Ores *and* Iron-Industries *of the* Salem District, *by* THOMAS H. HOLLAND, A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India.*

I.—Introduction.

The data and observations recorded in the following preliminary report on the iron resources and industries of Salem were gathered during a hurried visit to the district of less than three weeks, during which time I visited most of the places in which native iron-smelting is being carried on, and the principal localities in which the ores of iron occur. I have great pleasure in acknowledging the assistance which I have received during this short enquiry from Dr. H. Warth, Officiating Superintendent of the Government Central Museum, Madras, who accompanied me over a large portion of the tour. To Mr. G. Stokes, Collector of the district, both Dr. Warth and myself are indebted for the courteous assistance of himself and his staff, and for many suggestions in discussing the possibilities of developing the immense iron resources of the district of which he has charge. In investigating the question of local fuel supply, Mr Brasier, District Forest Officer, has rendered invaluable help in continuing the enquiry which had received the attention of his predecessor, Mr. W. Carroll.

II.—Literature.

Besides the previous information obtained under the superintendence of the Collector, Mr. Stokes, I have been guided in the enquiry by the following publications containing references to the native smelting and the iron-ore of Salem :—

1814. HEYNE, B.: Tracts on India.

1836. BENZA, P. M.: "Notes on the Geology of the Country between Madras and Neilgherry hills *viâ* Bangalore and Salem."—*Madras Journal of Literature and Science*, Vol. IV, p. 1.

1842. NEWBOLD, LIEUTENANT, Mineral Resources of Southern India: No. 3: Chromate of Iron Mines, Salem District.—*Journ. Royal Asiatic Society*, Vol. VII, p. 167.

1855. BALFOUR, E.: Report on the Iron-ores, etc., of the Madras Presidency.

1864. KING, W., and FOOTE, R. B.: "On the Geological Structure of portions of the Districts of Trichinopoly, Salem, and South Arcot. *Mem., Geol. Surv., Ind.* Vol. IV, p. 223, *et seq.*

1881. BALL, V: Economic Geology of India (Manual, Vol. III), pp., 332, 335 and 348.

1883. LEFANU, H.: Manual of the Salem District.

III.—Mineralogical and Metallurgical characters of the Iron-Ores of the Salem District.

I give below a list of the ores of iron found in the Salem district, making special mention of the peculiarities in physical characters which these minerals display in this area, and their respective metallurgical values:

Magnetite.

(1) *Magnetite* is by far the most abundant of the iron-ores of the area. It occurs either in well-defined octahedral crystals, (which frequently display polar magnetism), imbedded in chlorite, schist, as in the neighbourhood of Rakkiyapatti, 11 miles south-west of Salem, and Ettumanikampatti, an *inam* village a mile further to the south.[1] These are picked-up in large quantities in the rivers after heavy rains, and the natives, knowing their magnetic properties, string them together as beads.

Magnetite occurs also, making, with quartz, a schist in which the crystals of magnetite are crushed out in the direction of foliation to a roughly almond-shape, the proximity of the tapering points giving a lacunar appearance to the rock. Crystals of about one-half to three-quarters of an inch in length, and of this shape, are common in the iron-beds of Kanjamalai and of many other places in the district. All gradations in size are found down to an almost aphanitic rock in which the constituent minerals are, to the naked eye, indistinguishable as individual crystals—a type common to all the groups of iron-beds. Bands of magnetite sometimes alternate with quartz, or bands of quartz and magnetite, rich in the latter mineral, are found alternating with bands of the former, frequently contorted into fantastic patterns and giving the appearances characteristic also of lavas which have cooled down after fluidal movement in a semi-viscous condition. The magnetite and quartz-schists, in common with all the crystalline metamorphic rocks, have, in fact, derived their peculiar flow-structure from actual moulding under the enormous pressures to which they have been subjected during great earth movements. I have noticed that these contorted pieces of magnetite-bearing rock are commonest near the ridges which form such a prominent and characteristic feature in the outlines of hills in which iron-beds dip at high angles. This, I presume, is not only due to the actual resistance to the disintegrating action of the sub-aerial agents, but

[1] The village of Ettumanikampatti is, curiously enough, named from the octahedra of magnetite,—*Ettu* "eight"; *mani* "bead," *patti* "village." (Tamil.)

also to the tendency to resist jointing and its consequent production of small fragments which form a more easily moved talus.

Friable ore used by native smelters.

The incipient expansion of the mass, accompanying the oxidation and hydration of the magnetite, has, in many places, been sufficient to produce a rock which crumbles under the slightest blow, or even between the fingers. These are the pieces exclusively used by the native smelters on account of their friable nature. They are invariably found in the talus at the foot of the hills, and probably are simply the more weathered representatives of the compact specimens occurring in the beds above. A further form in which magnetite occurs in this district is that of segregation from the main mass of the rock into cavities and pockets, as innumerable small crystals, which in large fragments frequenty exhibit a distinct polarity of magnetism. Magnetite occurs also, together with small crystalline fragments of quartz, felspar, hornblende, garnets and other minerals, as sand in the river-beds, being derived from the disintegration of the numerous crystalline rocks within the area. In the trappean rocks, in granites, and in the more basic gneisses, magnetite occurs in disseminated grains, but not in quantities sufficient for economic use. In almost any locality in the south of Salem district a magnet dipped into a bed of river-sand becomes coated with large quantities of magnetic grains.

Distinctive characters of magnetite.

Magnetite may invariably be distinguished by its hardness. It is always attracted by the magnet and frequently is itself magnetic with well-developed polarity in large specimens. The colour, both in large fragments and in powder, is black, with a well-defined metallic or sub-metallic lustre. These properties serve to distinguish it from the other iron-bearing minerals mentioned below. Besides being the most abundant, magnetite is the richest ore of iron, containing, when pure, 72·4 per cent. of pure iron, the remainder being oxygen (Fe_3O_4). The ore which occurs in such abundance in the Salem district is thus the ore which has been used with such success in the Scandinavian iron-works. It was from this mineral, smelted with charcoal, that most of the famous Dannemora iron was produced. The Dannemora ore employed yielded on an average below 50 per cent. of the metal, varying between 25 and 60 per cent., whilst in the Salem district it is possible to obtain an almost inexhaustible supply of ore with an average of nearly 60 per cent. iron. This result is calculated from the average mineral composition stated by Messrs. King and Foote, and agrees with rough calculations of my own on crushed samples, as well as the estimate given by Balfour.[1] I have collected a large number of typical specimens which I hope to subject to analysis, the results of which will be embodied in the final report. I know of no published analyses of Salem ore giving the results of a search for such impurities as phosphorus, sulphur, and manganese; but from the reputation of articles of steel which have, in times past, been made from these ores by the well-known Arunachella Achari and others they must have been very free of at least both phosphorus and sulphur. Very small quantities of *phosphorus* would be sufficient to render the steel distinctly brittle and "cold short"—as little as 0·1 per cent. is the maximum amount of phosphorus allowed in rail specifications, and in good qualities of mild steel it seldom exceeds ·016 to ·04 per cent. There is one

Metallurgical value of magnetite.

Effect of phosphorus on steel.

[1] Cyclopædia, 3rd edition, vol. ii, p. 372.

point worthy of consideration in connection with this question, namely the tendency for the phosphorus in pig-iron production to pass into a basic scouring slag rich in iron, whilst a good, grey slag—desirable in most places for economy of iron—produced in smelting, yields almost the whole of the phosphorus originally contained in the ore, fuels, and fluxes to the pig-iron. Fluxes are used in most places for the purpose of economising the iron, lime replacing the iron in the compound silicate of the slag, but in this district the ore itself is so inexpensive that manufacturers can afford to lose a highly ferriferous slag for the sake of cleansing from phosphorus. Whilst I have no doubt these facts may account in some measure for the purity of the iron and steel produced by the highly wasteful processes of the native smelters, who use no flux beyond that afforded by the ash of the charcoal employed as fuel, it is still probable that the Salem magnetite is comparatively free from this impurity, which is a source of so much trouble to steel manufacturers. Ward's analyses of the Dannemora magnetic iron-ore show it to be free of both phosphorus and sulphur.

Phosphorus in "scouring" slags.

Cause of purity of native steel.

The presence of minute quantities of *sulphur* in steel is even more powerful in its influence on the properties of the metal than that of phosphorus. As little as 0·05 per cent. of sulphur is sufficient to render steel sensibly "red short," or almost unworkable at a red heat—a character which has never been ascribed to the Salem steels. To these points I hope to give special attention after careful analysis of both the ore and of the pieces of iron and steel which have been purchased from the smelters still at work in different parts of the district.

Sulphur in steel.

Hæmatite is seldom found in large crystals in this district. In the hills to the south of Namagiripett I found small crystals of specular iron in larger masses of crypto-crystalline hæmatite, forming, with quartz, a schist bedded in conformity to the adjacent magnetite-bearing seams. Frequently we find both magnetite and hæmatite intermixed with quartz and, in some cases, I have noticed magnetite cores surrounded by hæmatite to varying degrees—producing, in fact, minute crystals of *martite* which is probably, in most cases, pseudomorphous after the magnetic oxide. Hæmatite contains 70 per cent. of iron, and is notably free from sulphur and phosphorus. This ore, when smelted, invariably gives a pig rich in silicon a property which has increased its demand for the production of steel by the Bessemer process; and, before the modification known as the basic process was introduced, only pig-irons rich in silicon were suitable for Bessemer conversion.

Hæmatite.

Martite.

Pig-iron from hæmatite for Bessemer conversion.

Hæmatite in this district is quite subordinate in importance to magnetite. From the latter mineral it can be distinguished, when crystallised, by its higher lustre, red streak, crystalline character, and the absence of all magnetic qualities. I have collected specimens of "soft" (that is, specimens in which the ore is in excess of the free silica) hæmatite from the northern flanks of the Kollimalais, in the south-eastern portion of the Salem taluq. It is, however, sometimes found with quartz predominating, and even passing into a jaspery condition in several parts of the district.

Under the action of atmospheric influences, hæmatite takes up water and passes into *turgite* and ultimately into *göthite* and *limonite*, or *brown hæmatite*. These may be carbonated to produce the various forms of *clay ironstone* and *chalybite*. Various stages of these processes are represented amongst the Salem iron-ores, especially the production of small quantities of yellow ochre by oxidation and hydration of the magnetite. This is the cause of the friable property of the ore, which is, as before stated, preferred by the natives. But as none of these ores, however, occur in sufficient quantities to be of any value for metallurgical purposes in comparison to the magnetite and hæmatite, they will receive no further attention.

Turgite, Göthite, Limonite.

Clay-ironstone.

Pyrite is conspicuously free from the rocks of this district. Finely disseminated grains occur scattered through some of the intrusive igneous rocks, but not in large quantities.

Pyrites.

I have found small crystals of titaniferous iron-ore in some of the eruptive rocks of Salem, but have never noticed it occurring in large quantities. Captain Campbell has recorded his discovery of titanium in a black ore used by the smelters of the Salem district, but he gives no particulars as to the quantity or nature of the mineral in which it exists.[1] Captain Newbold also states that iron-ore, slightly titaniferous, is found over the whole "hypogene area of Southern India."[2] I have not yet subjected the specimens collected to an analysis; but I hope to give this point due attention, as it is one of metallurgical importance. Although a very refractory mineral, titaniferous iron-ore has been used in the bloomery furnaces of the United States and Canada for the manufacture, by direct process, of wrought iron. The fine state of division in which the ore occurs as sand is favourable to its treatment by this process. At Mosie in Canada it is found profitable to wash sands containing only comparatively small quantities of the titaniferous ore before treatment in, as far as I could learn, the ordinary American Bloomery Furnace with simply a reduction in the slope of the twyers and of the pressure of the blast. The mineral is further used with a certain degree of success as lining material in some kinds of revolving puddling furnaces. The titanium itself seems to produce little or no effect on the iron manufactured. It has never been, I believe, found in white pig-iron and it seems never to pass into the malleable iron made from grey pigs which contain titanium. The action of titaniferous ore is not so much due to the presence in the product of titanium as to the conditions in the blast furnaces which are necessitated by the presence in the charge of minerals containing that metal. I do not consider (with our present knowledge of the uses to which *titanium* can be put in iron manufacture) the presence of the mineral in the Salem district to be of immediate value. Although such an authority as David Mushet was so firmly convinced of the value of titanium in steel as to take out thirteen patents for his invention, its value is still an unsettled question. One thing is certain, that the higher temperature required for the smelting of titaniferous iron-ores means a larger fuel demand which seems to be about the only bar to success in working the Salem iron resources. It is stated that the Swedish Taberg ore requires more than twice the amount of fuel to smelt ores containing titanic oxide than to reduce ordinary magnetic oxide. It seems, therefore, that the proximity of

Titanoferrite.

Metallurgical value of titanoferrite.

[1] Campbell: *Calcutta Journ. Nat. Hist.*, Vol. II (1842), p. 280.

[2] Newbold: *Journ. Roy. Asiatic Soc.*, Vol. VIII, p. 155, and Vol. IX, p. 40.

this accessory does not increase the value of the iron deposits to any material degree.

Pyrrhotite or magnetic pyrites, although of interest on account of its remarkable properties, is of no metallurgical value. It occurs in small quantities in some of the rocks of this district as minute hexagonal prisms.

Pyrrhotite.

Ferruginous clays, limonitic pellets, ferruginous sands and *laterite* frequently occur in different parts of the district; but these iron-bearing deposits, although in some places valuable as sources of the metal and for building and other purposes, are, in this district, developed to quite an insignificant degree beside the enormous deposits of richer iron oxide.

Ferruginous clays and laterite.

Chromite in many respects resembles magnetite, having like it a black colour and sub-metallic lustre. It crystallises in the same form and has about the same hardness, whilst its specific gravity does not differ from that of magnetite sufficiently to allow of such a means of discrimination between hand-specimens of the two minerals. It is also sometimes magnetic. The property which at once distinguishes it from the magnetic oxide of iron is the colour of its powder. Chromite gives a brown streak, whilst that of magnetite is black. In chemical composition it differs from magnetite in a replacement of the iron sesqui-oxide wholly or partially by the corresponding chromic oxide. Besides the value of this mineral for the production of the various chrome-salts used as pigments, its use as an introduction into steel and iron adds to its value on account of its proximity to the rich iron-ores of Salem. Ferro-chrome has a decidedly beneficial effect on steel, and only the expense of the ore, and the difficulties attending the smelting of such an easily oxidised metal as chromium, prevent its more extended use in steel manufacture. It is, however, coming into great favour specially in Sweden, where the ores of iron are, in many respects, similar to the Indian ores, both in properties and mode of occurrence. In Tasmania chromic ores containing sulphur have been considerably smelted, although the presence of sulphur necessitates the expensive remelting of the pig with ferro-manganese. Whilst for rails its price will probably always prevent it superseding ordinary carbon-steels, the use of chromium-steel for the manufacture of armour-piercing projectiles seems to be decidedly on the increase, and the only substance which seems capable of replacing it to any extent will be a modified form of the remarkable manganese-steel recently made by Mr. R. A. Hadfield. For want of available literature I am unable at present to quote any data showing the enormous hardness, tenacity and great resistance to impact possessed by chromium-steel, but it may with safety be said that the attention which this alloy will in all possibility receive would make the presence of chromium in the Salem district a valuable accessory to the iron. In the sequel I shall show that the conditions which invariably accompany deposits of chromite are present not only on the chalk-hills in Salem, but are repeated in every respect at the foot of Kanjamalai itself, the hill so well known for its iron-beds from the interesting description by Messrs. King and Foote in the memoir already referred to.

Chromite.

Chrome-pigments.

Chromium in steels.

Chromium-steel projectiles.

Hadfield's manganese steel.

Possible occurrence of chromite in Kanjamalai.

Manganese ores.

Manganese ores.—The principal remaining substance of value in the manufacture of iron and steel is manganese. Although there are, as far as I know, no deposits of these ores in the Salem district, *braunite* is said to occur in the Kurnool district and near Tumkoor in Mysore. Notwithstanding the recent impetus given to the use of manganese in steels, I do not consider that these places—which are the nearest known manganese-bearing localities—are sufficiently near Salem to be worth considering in the question of the successful revival of the Salem iron-industry. They will be treated more fully in dealing with the respective localities in the final report. I can only call attention to this *possible* means of adding to the chances of development of the district at present under consideration.

IV.—Distribution and geological relations of the Ores.

Concerning this question I have very little to add, beyond the mineralogical notes already given, to the descriptions published, in 1864, by Dr. King and Mr. Foote in the memoir above quoted, and to the additional summary written by Mr. Foote for the District Manual (Volume I, pp. 97-102, and occasional references under the headings of the different talúqs in Volume II).

Additional remarks on the Kanjamalai iron-beds.

As to the celebrated iron-beds on Kanjamalai, I have been able to work out the exact points of junction of two of the beds with the adjacent rocks by working along the top of the westerly extension of the high ridge. In his description of Kanjamalai, given as an appendix to the memoir, Mr. Foote states his inability to decide on the thickness of the deposits owing to the manner in which the lines of junction of the beds are obscured by the debris rolled down from above (p. 382). A thickness of about 50 feet is estimated for each of the two lower beds. But, as stated, the exact thickness is of little importance when the quantity of ore is so enormously great. My actual measurements on the western ridge of two beds showed that even this estimation is rather understated. One bed measured nearly 50 feet, whilst the other was very little under 100 feet in thickness. The thicker of these beds is possibly the lowest (No. 1) of Mr. Foote, whilst the thinner seam below would, in that case, be unrepresented on the main mass of Kanjamalai. The reasons for this statement, although the results of a necessarily hasty examination, I will state presently. The iron-beds are described and mapped as concentrical ellipses ; but had Mr. Foote the privilege of re-examining the ground he would probably make a slight modification of his map on the north-west side of the hill. Although the modification is of little concern as to the iron resources themselves, I hope to show that the disturbances on the north-west side have given rise to a recurrence of the conditions which prevail near the chromite-deposits of the Chalk Hills, and thus becomes of possible economic value, as well as of scientific interest.

Thickness of beds.

Geology of western extension of the Kanja ridge.

Crossing the road in the southerly direction near Sithaswaran Kovil, one mile east of the village of Kadiampatti, one meets first with talcose and chlorite-schists exposed in the river-bed, and giving the general east-north-east and west-south-west strike of foliation, with a high dip to the north-north-west. For a few yards further the rocks

are covered with soil and the next exposure is that of a coarsely crystalline hornblende felspar rock with large garnets. This rock follows the general direction of foliation, but unlike the talcose and chloritic schists referred to, its dip is towards the mountain, and of 55°. There is probably thus an anticline to the north with its axis parallel to the direction of foliation. This rock is succeeded by a narrow dyke of basic rock intruded in the direction of strike, and following this we have a parallel arrangement of other foliated rocks, some with garnets, some without, and one or two eruptive rocks, all following a general east-north-east direction until the base of the mountain is reached, when they disappear under the talus of broken fragments of rocks fallen from steep slope above. The rather broken and low ridge of these rocks forms the northern boundary of an irregular depression which is backed in the easterly direction by the main mass of Kanjamalai and on the southern side by heights rising to 650 and 950 feet above the plain and forming the continuation of the main ridge of the mountain. It is within this depression that the complications of the strata to which I have referred occur. In the westerly direction the rocks are found to have a strike of almost due north and south and dip at about 50° or 60° towards the mountain, that is, towards the east. This direction changes for a north-west and south-east strike on ascending the hill to the south, and on following the ridge to the east the strike curves round to the west-south-west and east-north-east direction with, in the main mass, a northerly dip as shown in the section given by Mr. Foote (*loc. cit.*, p. 380). By this means beds which formed the base of the main mass of the mountain are brought obliquely across the westerly ridge, and on the edge of the ridge are laid bare for examination. Of the two beds so exposed, the lower and thinner rests on a garnetiferous, foliated hornblende-felspar rock. Between the two beds there is a thin seam of hornblendic gneiss about 20 feet thick—an occurrence nowhere described in the memoir. I conclude, therefore, that the heavy debris obscuring the beds on the main hill-slopes concealed this thin bed of gneiss from the observation of the original observers, whilst if this large bed, which bends around to the north-west, is a continuation of their bed No. 1 from the southerly side, then I have missed, in my hasty climb, the thin indurated bed of talcose schist (*loc. cit.*, p. 380, fig. 9). This is very possible as the task of working up towards the summit was by no means facilitated by the rolling boulders and thick, thorny tangle of bushes. The two highest points on this westerly extension were, by aneroid readings, respectively 650 and 950 feet above the plain, and from the last point to the summit, and down over the northern slopes, my observations coincided precisely with the account given by Mr. Foote.

Anticline to north of Kanja.

Exposure of iron-beds on the western ridge due to change in direction of strike.

In the depression on the north-west corner there are ramifications of a great dyke of graphic granite running generally parallel to the foliation, but in places cutting across the gneiss. Further complications are brought about by the intrusion of black hypersthene-bearing and other pyroxenic rocks, which seem to have been intruded in order from the basic rocks to the acid granite. Towards the west quartz-veins bifurcate and ramify amongst the basic gneisses; but the most interesting feature is the occurrence of veins of *magnesite* traversing precisely

Intrusive basic and ultra-basic rocks on the north-west side.

Magnesite.

the same kind of decomposed and crumbling rock as we find in the sides of the chromite shafts on the northern magnesite area of the Chalk hills near Salem, It is associated also with compact, and sometimes fibrous serpentine or picrolite (baltimorite). As the occurrence of these minerals in Kanjamalai has not been recorded by Messrs. King and Foote, a description and a comparison of the essential geological features of this area and of the Chalk Hills will explain my reasons for considering the occurrence of chromite in the Kanjamalai by no means an improbable discovery.

Fibrous serpentine.

Lieutenant Newbold, in one of his series of communications on the mineral resources of Southern India to the Royal Asiatic Society, described the chromite-mines of the Chalk Hills. This paper seems to have been overlooked by Messrs. King and Foote, who, consequently, could say little as to the mode of occurrence of the chromite. The mines were also inaccessible at the time of their visit, but since that time the rubbish, which has fallen in from the sides of the shaft, has afforded a convenient soil for the growth of a tree (*Ailanthus excelsus* or *Pi-maram*) in each of two of the shafts. These are now grown to the mouth of the shaft and stand in striking contrast beside the stunted shrubby acacias of the surrounding area. By one of these trees I managed to climb down to the bottom of the shaft, now only 35 feet deep, and my observations, on the walls and of the fragments at the bottom, confirm Newbold's description of the mode of occurrence of the chromite.[1] At the time of Lieutenant Newbold's visit, the shafts were respectively 59 and 63 feet deep, but since that time a third shaft has been made and a few smaller excavations, apparently of a trial nature, are still to be seen about the immediate neighbourhood. Water was found in quantity at 59 feet, but the workers possessed no better means of removing it than by the use of ropes and buckets. The ore follows the direction of the magnesite-veins, but is found generally between the magnesite and the main mass of crumbling rock. One large mass, weighing 2 tons, was also found before Newbold's visit At present the only chromite visible is in small quantities lying in the manner described above. I have collected specimens of the ore for further examination. An analysis by Mr. E. Solly of a piece collected by Lieutenant Newbold yielded 49 per cent. of chromic oxide and resembled the material brought from America and from the Shetlands.

Chromite mines of the Chalk hills.

Observations in the chromite-mines.

Mode of ocurrence of chromite.

Judging from analogy of other occurrences of chromite and its constant associate, serpentine, the formation in the Chalk Hills is not improbably the remains of a great ultra-basic intrusion. I have found dykes of undoubtedly basic and ultra-basic rocks in the neighbourhood, and serpentine has, in many instances, since the date of the publication of the Survey memoir, been proved to be the hydrated product of the highly magnesian constituents of ultra-basic and olivine-bearing, igneous rocks. The rock known as *dunite* from New Zealand contains chromite imbedded in olivine, which has, as yet, only suffered the incipient hydration to which olivine is undoubtedly susceptible. The same dykes of

Paragenesis of chromite.

Dunite.

[1] *Journ Roy. As. Soc.*, Vol. VII (1843), pp. 167-71.

ultra-basic rock, the same decomposed material, bearing magnesite in similar veins, and serpentine both in its fibrous and in its compact form, are all found at the north-west base of Kanjamalai. Whilst it is to be admitted that chromite is most irregular in its distribution amongst these rocks, there remains the suggestive fact that these conditions are precisely those under which the mineral is invariably found; and I think it is at least worth more than the search of the few hours which were at my disposal. Nothing but a careful working out of the petrological relationships of these rocks will result in successful prospecting for valuable minerals.[1]

Same phenomena in Kanjamalai.

Search for chromite suggested.

Messrs. King and Foote are unconsciously unfair in their criticism of Dr. Benza's observations in the Chalk hills. Dr. Benza did not, as they imagined, overlook the serpentine, either in its ordinary or in its fibrous form. Dr. Benza could not be expected to call the mineral by the name of *baltimorite* for the very obvious reason that this name was not coined until seven years after the publication of Benza's interesting paper. The author of the term *baltimorite* was himself quite unconscious of the affinities which the mineral possessed for serpentine and proposed the word, as he did many others, in the indiscriminate manner characteristic of the times when mineralogy was less of a science than postage-stamp lore! The word *picrolite* was used for this form of serpentine as long ago as 1808, and has the preference both in age and scientific accuracy. Baltimorite can offer no apology for its existence. I have referred to this point because it explains the terms used by previous writers on he geology of Salem—Heyne, Benza, and Newbold. The last two authors both spoke of the existence of asbestos and nephrite,[2] whilst Heyne referred to a "semi-pellucid greenstone" which is about the hardness of serpentine and looks not unlike the famous image stone of China.[3] The confusion which existed at that time between the complex minerals nephrite, jadeite, bowenite, and agalmatolite (which is used at the present time for ornamental carvings in China and elsewhere), and the varieties of serpentine, explains the use by Benza and Newbold of "nephrite," whilst the interesting circumstances attending the examination of the original specimen of baltimorite explains the term "asbestos"—the name under which it passed before coming into Professor T. Thomson's hands. Curiously enough it was labelled "asbestos with chrome."[4]

Benza's discovery of serpentine in the Chalk hills.

Picrolite and baltimorite.

"Nephrite" and "asbestos" of Benza and Newbold correspond to "serpentine," and "picrolite" (baltimorite).

With regard to the place mentioned by Benza as a further locality for magnesite, namely Yedichicolum, close to the Cauvery, near Trichinopoly, Messrs. King and Foote have expressed some doubt. I hope to investigate this matter on taking up the Trichinopoly district; but, in the meanwhile, I might mention that Newbold

[1] Since writing the above in camp, I have examined, in the laboratory, specimens collected on Kanjamalai and on the Chalk hills, and find that in each case the magnesite is formed, as suggested, by the decomposition of olivine-rocks closely related to dunite.—*T. H. H.*

[2] Benza: *Madras Journ. Lit. Sci.*, Vol. IV (1836), p. 23.—Newbold: *Journ. Roy. As. Soc.*, Vol. VII (1843), p. 168.

[3] *Cf.* King and Foote: *Op. cit.*, p. 241.

[4] Thomson: *Phil. Mag.*, Vol. XXII (1843), p. 191.

Photo[d] by T. H. Holland. Printed Geol. Survey Office

PARIAHS SMELTING WROUGHT IRON, SALEM DISTRICT.

also refers to the same place as containing, not only magnesite, but chromite, and he further refers to "Hoonsoor, Mysore and to a site near Comarpollium, 10 or 12 miles south-west from Sankerydroog, in the Salem district."[1] Of other occurrences of chromite in India the same association with serpentine has been recorded. Amongst these I may refer to samples found by Mr. Mallet weathered out of the serpentinous rock of Spiti[2] and in one or two places in the Andaman Islands.[3]

I have already referred to the increasing value of this mineral.

Remaining groups of iron-ore beds described by King and Foote.

With regard to the remaining groups of iron-ore beds described in this memoir, my observations confirm the descriptions of them in every particular and the time would not allow of extending the details. These groups will be referred to in discussing the fuel supply.

V.—Native smelting processes.

At the present time both wrought iron and steel are being manufactured by pariahs in the Salem district; but I nowhere found steel (*wootz*) being *made in crucibles*, as, according to previous writers, was the case when the industry was in a more flourishing condition. Wootz, however, is still being made in the adjoining district of Trichinopoly.

Manufacture of wrought iron.

The process of manufacturing the wrought iron is simply a very primitive and imperfect form of the Catalan and Bloomery process at present employed in Europe and America. The furnaces are smaller and much more imperfect in every way than the furnaces which I saw in the Ernad talúq of the Malabar district. The mode of working the bellows is also different from that of the western workers, who are in the employ of Mahommedan moplahs. The process of smelting one bloom occupies about two or three hours, the resulting iron weighing about 18 lbs., whilst the Malabar workers occupy as many days for the production of a bloom of iron weighing about 5 cwt. In Malabar also the charcoal and iron are all weighed and the products sold by weight in four grades, whilst in Salem the workers do everything by guess, with the result that there is an enormous waste of either ore or fuel; and the sale of the bloom is a bargain at sight without regard to weight. The pariah workers seem to possess little sense of either time or weight, and professed great amusement at my suggesting some simple improvements on the method which they and their ancestors had practised all their lives! (Plate I.)

Comparison with Malabar workers.

Mining the ore.

The processes of mining (or "grubbing," for the diggings are never more than 3 feet deep) the ore are even more wasteful than the smelting. Only the well-disintegrated and rotten pieces of quartz-magnetite schist are used. All the pieces too hard for easy crushing, even nearly pure magnetite, are rejected, and, consequently, the material contains not only large quantities of quartz-grains, which have to be removed in preparing the ore

[1] *Journ. Roy. As. Soc.*, Vol. VII (1843), p. 169.

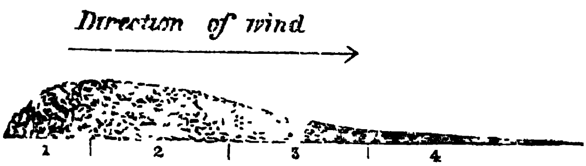
[2] *Mem. Geol. Surv. Ind.*, Vol. V, p. 167.

[3] *Rec. Geol. Surv. Ind.*, Vol. XVI, p. 204; Vol. XVII, pp. 83 and 84. The serpentine has been mapped by Mr. R. D. Oldham (*Rec. Geol. Surv. Ind.*, Vol. XVII, pp. 135, 145 and plate).

for smelting, but, in addition, a considerable amount of limonitic dust which is also carried away in the subsequent process of cleaning the magnetite.

Dressing the ore.

In dressing the ore the large fragments are crushed with a flat hammer, about 3 inches square, one man using the hammer, whilst the other is continuously heaping the larger fragments into the central part of the pile. After sufficient material has been accumulated, the crushed rock is winnowed by pouring out of a basket in a strong wind. The heap which so forms is divided into four portions, as shown in the accompanying sketch-section. No. 1, consisting of large pieces, is to be re-crushed. No. 2 is



cleaned of its quartz by sifting in a shallow basket similar to that which is used for separating rice from the husk and for sifting coffee to remove the imperfect berries. Towards the end of the concentrating process the fragments which find their way to the lip of the basket are compound grains of quartz and magnetite; these are dropped back upon the pile for re-crushing, instead of being thrown away with the quartz waste. When the magnetite is well concentrated, it is taken in this state to the furnace, but has still to the re-crushed and sifted before it is fit for smelting. This last process, however, is carried on near the furnace. No. 3 of the winnowed pile is composed of *fine* grains of quartz and magnetite, and the concentration is brought about by washing in the river. The workers are, from practice, evidently

Washing the ore.

aware of the fact that reducing the specific gravity of each mineral by 1 gives the magnetite a greater proportional weight over the quartz, for that of course is the principle on which they adopt washing in preference to sifting for the finer particles. Section No. 4, consisting almost wholly of limonite-dust, is rejected as useless.

Steel manufacture by de-carburisation.

The process of smelting for wrought iron has been so well described by previous writers that I will add no more in the present preliminary report. But the manufacture of steel is so altogether distinct in principle and practice from any native process which I have seen described that I will give an account of the operation which I examined in one or two places. In 1840 David Mushet published an account of his elaborate experiments on the samples of wootz, submitted to him [1]; and, in referring to Mr. Heath's paper to the Royal Asiatic Society, he was puzzled at the two kinds of steel which were brought to England from India. The steel was sometimes brought in the form of conical ingots and sometimes in flat, round cakes. The former kind was evidently the ordinary wootz, as still made in crucibles in Trichinopoly. The latter kind is now made in the Salem district, but by a process quite different from that of the crucible wootz. Heath, in his paper,

[1] Papers on Iron and Steel, 1840, p 650.

T. H. Holland

Records Vol. XXV. Pt. 3 Pl. II.

Photo^d by T. H. Holland

Lith^d & Prt^d Geol. Surv. Office

PARIAHS MAKING STEEL, SALEM DISTRICT

seems to have overlooked the latter process, and, as far as I am aware, it has been generally left out of descriptions of the native smelters. The conical ingots of wootz are made by *the carburisation of wrought iron in crucibles*, the principle which was not applied in England until 1800, and which governed the later patent of Mackintosh, and since modified to the modern cementation process for the conversion of bar-iron into " "blister steel," and in "case hardening." The flat cakes of steel now being made in the Salem district are, on the contrary, produced by the partial removal by oxidation of the carbon in cast iron, as in the open-hearth finery of Styria and Carinthia, and in the ordinary puddling of pig-iron. The former material is made by *carburisation* and the latter by *de-carburisation*. The following is the process as now carried on:—

Steel-making process in Salem.

In the manufacture of wrought iron, certain easily fusible beads of iron are produced and melt off as shot. These are in reality highly carburised particles, or cast iron, and it is from these that the steel is made. The shot are first pounded in a stone mortar with a wooden pole guarded with an iron ring—the *olakai*, used for pounding rice. By this process the small particles of slag adhering to the shot are removed, and the cast iron receives an imperfect polish. The powdered slag-material is separated by sifting in the ordinary manner in a *moram*, or shallow basket. A hole is dug in the ground about one foot deep and about one foot in diameter. At one side a semi-circular groove is excavated from the surface to the bottom of the pit. A large cake of soft clay serves to divide this small excavation from the other part of the pit, and the smaller chamber serves as the finery in which the steel is made. The bottom of this is first covered with a layer of dirty quartz obtained from sifting the crushed ore, as described in the process of dressing the magnetite for the furnace. There are generally pieces of magnetite adhering to this quartz, which fact accounts for the "orey particles" in the cakes of steel produced, and which so puzzled Mushet to explain, and from which he concluded the steel must have been produced direct from the ore. On this hearth of quartz an ignited coal is placed and the small chamber filled with charcoal. A tuyere, previously built in with the clay partition, points downwards at an angle of about 45° and receives the nozzles of two goat-skin bellows, by which a continuous blast is maintained. The shot are first wetted and thrown upon the charcoal, the amount used being governed by pure guess-work as in the wrought-iron smelting. The blast is continued for about half an hour, when the process of decarburisation is complete, and the tuyere and clay-partition broken down for the removal of the steel-cake, which is first slightly cooled by a dash of water and then hammered to remove the casing of slag which has formed around it. I have secured several cakes of this material, and hope to subject them, as well as the cast-iron shot employed, to experimental tests in the laboratory. The workers are quite aware of the fact that if they continued the process too long, the resulting product would be of no more use than ordinary wrought iron, although, of course, they do not know that the removal of the carbon, which gives the steely properties to iron, is the result of continued oxidation. The cakes of steel which result are sold for 4 or 5 annas each. (See Plate II.)

It seems curious that these pariahs should adopt this interesting process for the manufacture of steel, whilst the typical wootz is made in such an entirely different manner. They professed ignorance of any method other than that which

they now employ, and they have been carrying on this method as long as any of them could remember. Regarding the conservatism of these people as a constant, one might suspect their industry to be of independent origin and they of a different caste from the wootz-makers still at work in South Trichinopoly. It will be interesting to cross-examine the wootz-manufacturers on this point.[1]

Localities in which smelting is carried on.

In the Salem district smelting of iron is confined to the Salem, Trichengode and Attúr talúqs, the work which was formerly carried on in the talúqs of Namakal, Úttankarai, and Hosur having been given up as profitless. At most of the places where smelting has been, or is being, carried on, I noticed large heaps of ashes and slag, sometimes 10, 15 and 20 feet high, with, in one or two cases, trees of one foot or more in diameter growing on the heaps.

During our visit Dr. Warth and myself found and examined smelters and their furnaces in the following places:—

(1) SALEM TALÚQ.

Námagiripett.—Several slag-heaps and groups of furnaces for the manufacture of both iron and steel. Ore is obtained from one of the outlying low hills of the Kollimalais, about 3 miles south-east of the village. Fuel was obtained from Kadiampatti and Mullu-kurichi forests, about 10 to 12 miles from the furnaces.

Perumapalayam, about 1½ miles north-east of Karipatti. A large slag-heap and the remains of two or three furnaces. Smelting carried on last a year ago, when ore and fuel were obtained from Godumalai, ½ mile from the village. When the work was in a more flourishing condition, ten years ago, fuel was also obtained from Thaimalai, a distance of 2½ miles.

Tirúmanúr, 7 miles south of Karipatti. Ore obtained from 2½ miles north of the village. Charcoal from wood in the forests around the place. One furnace working; the remains of others standing.

From enquiries, I heard there were smelters at work in the following additional places in this talúq:—

Konganapuram, 7 or 8 miles west of Kanjamalai, which is the source of the ore.

Vanavási and *Soragai*, both places near *Nangavalli*, 21 miles north-north-west from Salem *viá* Taramangalam.

Twenty or thirty workers are said to be still smelting in these villages.

(2) ATTÚR TALÚQ.

Attúr.—A slag-heap with remains of six furnaces for wrought iron. One for iron and one for steel still at work owned by one Sanyasi Pariah in Kattyakara Street. Ore is obtained from Múragathúmalai, 4 miles west-south-west of Attúr, and fuel from a distance of 6 miles.

Thondaroyapuram or *Meykapalliar*, 4 miles west of Attúr. Three furnaces worked for the last time in January 1892. Ore from Muragathúmalai, 1 mile to the south-east. Fuel from same range of hills.

[1] Since this was written I have examined the makers of crucible-wootz in South Trichinopoly and find they are of the Karuman caste. A description of these workers is given in a separate report.—*T. H. H.*

Mathurúlú, 3 miles west of Mallikarai. On account of the present scarcity work stopped for a month. One smelter was about to make a bloom at the time of my arrival, and, on its completion, I bought it for 5 annas. He said the ore was obtained from the Godumalai and fuel from Poonamalai, 1½ miles from the village.

Keerapatti, 2 miles south of Mallikari. Smelters worked up to February 3rd, 1892, and find it, at this time, more payable to do cooly work, principally in cutting firewood. There were five furnaces on a slag-heap 2 feet high. The working has been carried on in the place little over two years, the smelters having come from Mathurúlú, Nahempatti, and Meykapalliur. Charcoal obtained from Válakumba, 2½ miles east. Ore from Nahempatti, 4 miles south.

Nahempatti, on the road to Tammampatti. Some ore may be obtained close to the village, and more 1 mile to the east in the Parmamalai. Charcoal from Taletalai kaidú, a distance of 4 miles. Slag-heap, 10 feet high. Banded magnetite-quartz schist is used here for road-metal.

Tammampatti.—Five good furnaces, but none of them worked for nearly six months. Slag-heap 15 feet high. Ore from Parmamalai, 2½ miles north-east of furnaces, the ore which occurs within a mile to the north being neglected. Fuel was obtained from Válákumba forest, 2 miles west.

Chendarapatti, 2 miles east of Tammampatti. One furnace at work. Ore from 5 miles east, Kudúmalai. Slag-heap 10 feet high, with remains of four other furnaces.

Tukkiampalayam, 2 miles north of Valaipádi. Three good furnaces and remains of eight others. The only variation I have ever found in the shape of the furnaces was the use of a square and more strongly built base at this place. Ore brought from the Godumalai in the Salem talúq. According to the statement of the pariahs charcoal from 10 miles.

Smelting is not now carried on at *Nárakanar*, 6 miles north-west of Tammampatti and *Kadambúr*, 7 miles south of Attúr, localities in which a thriving industry was formerly carried on.

(3) TRICHENGODE TALUQ.

In the Sankaridrug division, ore from Kanjamalai is still smelted by pariahs in the following villages:—Valayasettipalayam, Konganapuram, Iruqaluruttapalayam, Padavedu and Ayigoundenpalayam. In six other villages, where the industry formerly flourished, it has now died out.

The workers unanimously say that the increased price of fuel has been the cause of reducing the industry, and many of the workers have lately stopped on account of the present scarcity and consequent small demand for the iron for implements. Although this cessation of work may be only temporary, it is possible that this might in many of the villages be "the last straw" on a dying industry.

VI.—Fuel Supply.

For the production of charcoal the favourite wood seems to be the *Wúnjai* (*Albizzia amara*)—the *Oosulay* of Malabar. The timber is extremely hard and

mottled with concentric, alternating light and dark bands. It is said to be extensively used for fuel on the locomotives in Salem. I have secured specimens of the wood and its charcoal for the purpose of determining its calorific power and other properties in the laboratory, and for the estimation of its ash. I have also secured specimens of three other, but less favourite, woods used by the pariahs:—

Sembalichán (*Erythroxylon* (*Sethia*) *indica*), a dark-brown wood.
Nekani (*Canthium didymum*), a small tree with hard, grey wood.
Woodavai (? *Adave* of Manual) (*Grewia rothia*).

Details concerning the supply of fuel available from these forests have been submitted to the Madras Government by the late Acting Forest Officer, Mr. W. Carroll. This information has been conveniently arranged with reference to the main groups of iron-bearing beds, following the classification of Messrs. King and Foote, and divided between the talúqs of Salem, Attúr, Námakal, and Uttankarai.

In the *Salem talúq*, from the 47,800 acres of available forest, Mr. Carroll estimates from a clean felling 11,472 tons of timber, which would produce 2,699·3 tons of charcoal—sufficient probably to manufacture 830 tons of iron. A partial clearing of the forest would allow of little less than half this yield.

In the *Attúr talúq*, the yield of timber is estimated in the present state of the jungles to be 833 tons per annum—a quantity sufficient only for the manufacture of 58 tons of iron.

In the reserved portions of *Námakal talúq* a partial clearing would give 2,816 tons of timber—sufficient fuel, when converted into charcoal, for smelting 220 tons of iron. To this must be added a probable yield of 2,550 tons from the unreserved portions, giving 196½ tons of iron.

Uttankarai talúq has an available forest, reserved and unreserved, of 31,946 acres; this amount is within a radius of 5 or 6 miles from the Thirthamalai magnetic iron-beds. The reserved portions would, with clean felling, yield 7,000 to 8,000 tons of timber, and with partial felling, 4,000 tons—equivalent to about 1,000 tons of charcoal. The unreserved portions of 4,100 acres giving a yield of 2 tons per acre would with a 20-years' rotation give only 410 tons of charcoal. Taking these two quantities together we have sufficient charcoal in Uttankarai to manufacture 433 tons of iron. The jungles lying east-north-east and south of Thirthamala reserve would on the above rotation yield sufficient charcoal for an additional 192·3 tons of iron.

We thus have in the vicinity of the iron-bearing beds sufficient timber for the following yield of iron per annum:—

		Timber.	Iron.
Salem	*talúq*	5,736 tons.	400 tons.
Attúr	"	833 "	58 "
Námakal	"	5,366 "	416 "
Uttankarai	"	8,140 "	625 "
	TOTAL	20,075	1,459

Statement showing the number and names of the Magnetic Iron-ore beds within the Salem talúq, the Forests nearest to them, and the probable quantity of Fuel to be had from them, etc.

Name of group.	Names of forests, reserved and unreserved, nearest to the group.	REMARKS.
1. Kanjamalai.	1. Bodamalai . 2. Mallúr 3. Nagaramalai 4. Jallathu 5. Suriamalai 6. Vanavasi . 7. Pakkanad .	The first four jungles lie within the Salem talúq and the other three in that of Trichengode: the nearest are Nos. 1 and 2, "Bodamalai and Mallúr," which are from 10 to 12 miles away as the crow flies and from 20 to 22 by the cart road. As the cost of manufacturing iron was found to be so very costly in 1861 (*vide* District Manual, page 99), and had to be abandoned, much more so now, as more will have to be paid for fuel, labour for cutting same, and converting into coal, etc., that I don't think it would be worth while for any company to start the industry again. There are of course other scrub jungles nearer, mostly within mitta limits, but the fuel to be had will very soon be exhausted, as the tract contains chiefly scrub growth.
2. Godamalai and a small portion of 3 Singipatti.	1. Jallathu . 12,000 acres 2. Godamalai 5,600 " 3. Vellampatti 5,500 " 4. Kuruchi . 2,300 " 5. Illapadi . 3,600 " 6. Kudmaduvu . 4,300 " 7. Pungamaduvu . 2,500 " 8. Kombakal 8,000 " 9. Manjavadigha, one-half . 4,000 " TOTAL . 47,800 acres	The iron beds of this group (*vide* District Manual, page 100) extend from a point 7 miles east by north of Salem along the Godamalai ridge, then past Belur north-eastward up the Nayamalai, and thence along the eastern slopes of the Tenandimalai for many miles; the last-named hill lies in the Uttankarai talúq. The forests within 5 miles of this group on either side are noted in column 2. Their aggregate extent will be about 47,800 acres, or a little over 74 square miles. The first three noted contain poor growth, while the others may be classed as middling to very good. The average outturn per acre, if a clean felling is made, can be set down at 6 tons, and at 3, if partially cleared, that is, if all the trees suitable for timber are left—taking the yield at 6 tons an acre, and allowing for a rotation of 25 years, the nine jungles named will yield $\frac{47,800}{25} \times 6 = 11,472$ tons as from 4 to $4\frac{1}{2}$ tons (average $4\frac{1}{4}$) of fuel are required for giving 1 of coal, the outturn in coal will be $\frac{11,472}{4\frac{1}{4}} = 2,699\cdot3$ tons, or sufficient to manufacture a little over 830 tons of iron, if $3\frac{1}{4}$ tons of coal are required before one of iron (*vide* page 99 of the District Manual). If, however, it should be decided to make a partial clearing only, then the outturn in iron will be about 400 tons only.

Statement showing the Jungles bordering the Iron beds of Singipatti or Singipuram and of Kollimalai in the Attúr talúq.

Name of group.	Names of Jungles.	Extent.	REMARKS.
1. Singipatti or Singipuram.	1. Godamalai 2. Jallathu 3. Manmer	Acres. 5,600 12,000 4,000	This group (quoting from the District Manual, page 100) lies 4 miles south of the Godamalai and extends some 10 miles in a generally east-north-east to west-south-west direction. The forests bordering same and within 5 miles on either side are noted in column

Statement showing the Jungles bordering the Iron beds of Singipatti, etc.—contd.

Name of group.	Names of Jungles.	Extent.	REMARKS.
1. Singipatti or Singipuram—*contd.*			2. In addition there are several patches of unreserved land containing very poor growth, so that the fuel for the working of this group will have to be drawn from the reserves noted. The first two have already been entered in the statement for Salem talúq. The other "Manmer" contains very little growth and will not yield more than 1 ton of fuel per acre. The slopes of the Periakalroyan are a little farther off, but I don't think it would pay any company to get their fuel or charcoal from these, so that the Godamalai and Jallathu reserves are the only two from which fuel to a limited extent can be drawn.
2. Oilpatti.	*Nil.*	*Nil.*	There is no mention made of this bed in the District Manual, probably owing to its being so very insignificant, but as iron ore is to be had there I have entered it in this statement. The range of hills through which the bed passes is unreserved land, but has been marked off as one that should be reserved. The growth within 2 or 3 miles of the locality mostly consists of scrub fit only for fuel. The extent (approximate) may be set down at 5,000 acres and the average yield at 2 tons per acre. If worked on a rotation of 12 years which is sufficient for the regrowth of Thuringe (*Acacia amara*), the yield per annum will be $\frac{5{,}000 \times 2}{12} = 833$ tons or sufficient to manufacture a little more than 58 tons of iron.

Statement showing the number and names of the Magnetic Iron-ore beds within the Námakal talúq, the Forests nearest to them, and the probable quantity of Fuel to be had from them, etc.

Name and No. of group.	Name of Forests.	Extent in acres.	REMARKS.
	Karavalli Kombai, R. F. No 2.	8,750	The reserved and unreserved lands noted here form the whole of the Kollimalai range of hills in the Námakal talúq which, if worked on a rotation of 30 years will admit of $\frac{42{,}400}{30} = 1{,}413$ acres being felled over annually.
	Jambuthu, R. F. No. 3.	2,617	The first three, aggregating close on 17,000 acres, have been reserved under section 16 of the Act, while the others are still unreserved.
	Pulujansholai, R. F. No. 4.	5,530	The growth is very dense in parts and the average yield may be safely set down at 10 or 12 tons per
	TOTAL .	16,900	

Statement showing the number and names of the Magnetic Iron-ore beds, etc.—contd.

Name and No. of group.	Name of Forest.	Extent in acres.	REMARKS
4. Thalamalai—Kollimalai group.	Unreserved lands of the following nods :—		acre and from 5 to 6 tons if a partial clearing is made. Taking 5 tons as the outturn, the yield will be for the Reserved Forests $\frac{16,900 \times 5}{30} = 2,816$, which, when reduced to coal, will give a little over 700 tons. This quantity will suffice to produce nearly 220 tons of iron. The unreserved portions, if also worked on the same rotation, and if 3 tons per acre is set down as the average yield by partially working them, the outturn will be $\frac{\left(\frac{25,500}{30} \times 3\right) \div 4}{3\frac{1}{4}} = \frac{2,550}{4} \div \frac{13}{4} = \frac{2,550}{4} \times \frac{4}{13} = 196\frac{2}{13}$ tons of iron, or in all a little over 400 tons per annum. As from the District Manual, I find that the iron-beds are spread over "the whole area of the Kollimalai," all the extents noted will be within easy reach of the workings. The Belukurichi ridge, alluded to at page 101 of the Manual, lies within Mitta limits. The nearest Government jungles are on the western slopes of the Kollimalai, which, if worked, will be able to supply sufficient fuel to turn out at least 100 tons of iron annually.
	Selur nod .	6,000	
	Thevanur nod .	5,000	
	Thimmanur nod .	2,000	
	Vallapur nod .	2,000	
	Arur nod . .	3,500	
	Sundar nod .	5,000	
	Valluna nod .	2,000	
	TOTAL .	25,500	
	GRAND TOTAL .	42,400	

Statement showing the number and names of the Magnetic Iron-ore beds within the Uttankarai talúq, the Forests nearest to them, and the probable quantity of fuel to be had from them, etc.

Group, No. and name.	Name of Forests.	Extent in acres.	REMARKS.
5. Thirthamalai group.	Thirthamalia, R. L. 78.	11,046	Of the forest noted in column 2 the fourth known by the name of "Puvampatti" has been declared a Reserved Forest under section 16, while the first three are under settlement, and will ere long be also reserved under above section of the Act. Their total area (approximate) is 27,846 acres = 43·5 square miles. The remaining nine extents are unreserved lands aggregating about 4,100 acres, or 6·4 square miles, so that the total extent from which fuel may be had *within a radius* of from 5 to 6 miles of the Thirthamalai magnetic iron beds is 49·9 square miles, or nearly 32,000 acres. The reserved forests contain far better growth than the unreserved portions. If the former are worked on a rotation of 20 years, they will allow of nearly
	Veppampatti, R. L. 79.	8,640	
	Poyipatti, R. L. 75 .	3,488	
	Puvampatti, R. L. No. 50.	4,672	
	TOTAL .	27,846	
	Unreserved lands of the following villages :—		
	Endalur . .	500	

Statement showing the number and names of the Magnetic Iron-ore beds, etc.—contd.

Group, No. and name	Name of Forest.	Extent in acres.	REMARKS.
	Peria Pouni Maduvu.	800	1,400 acres being felled annually. If a clean felling is carried on, the annual yield will not be less than from 7,000 to 8,000 tons of fuel. On the other hand, if only a partial cleaning is undertaken, that is, after reserving all good timber, trees and saplings of good description and straight growth, then the yield will probably not be more than one-half the above figure, or say, 4,000 tons. As 4 tons of wood are required to give one of charcoal, the outturn of that product will be $\frac{4,000}{4} = 1,000$ tons. This quantity will admit of producing a little over 307 tons of iron (*vide* remarks on page 99 of the Manual). The unreserved extents, aggregating 4,100 acres, also contain in parts very good growth. The average yield per acre may be set down at 3 tons, that is, if a clean cutting is made, otherwise about 2 tons only taking the last figure for the purpose of arriving at the quantity of fuel that may be had, and working the extents on the same rotation as noted above, we will get $\frac{4,100 \times 2}{20} = 410$ tons per annum; this quantity will allow of a little over 126 tons of iron being made, or a total of 433, or, say, 440 tons annually. If jungles lying 2 to 3 miles east-north-east and south of the present Thirthamalai reserve are also worked for fuel, on the above rotation, from 2,000 to 2,500 more tons may be had annually, which produce $\frac{2,500}{\times 3\frac{1}{4}} = 192.3$ tons of iron. W. CARROLL, *Acting District Forest Officer,* G. STOKES, *Collector.*
	Srima Pouni Maduvu	800	
	Calla vudichampatti.	1,000	
	Tambal	300	
	Malasingambadi	200	
	Audiyur	200	
	Mondukuli	100	
	Alambadi	200	
	TOTAL	4,100	
	GRAND TOTAL	31,946	

Casuarina and blue-gum plantations.

The luxuriance with which *Casuarina* grows in suitable places exposed to moist sea air, as on the coast of Nellore, Chingleput, and South Arcot, will possibly, according to Sir D. Brandis, be a means of reducing the price of fuel sufficiently for its profitable conversion into charcoal.[1] He makes similar remarks concerning the fast-growing *Eucalyptus* of the hills. Although the increased yield per acre of timber available for fuel will undoubtedly bring down the price, I do not think it is so certain that fast-growing trees like *Casuarina* and the blue-gum will produce timber suitable for charcoal-manufacture. Without doubt they would replace, as fuel for the railways and towns, those *hard timbers* which are found to be suitable for charcoal, and so, indirectly, the cost of the carbonised product becomes reduced.

Slow-growing timbers.

As to the nature of the wood necessary to produce a good charcoal for smelting purposes we are comparatively in the dark. By experience the natives have discovered the preferable qualities of the

[1] [illegible] regarding Forest Administration in the Madras Presidency (1883), p. 54.

woods,—*irúl, wúnjai, sambalirhan, nekani,* and *oodavai,* and of these they show, in the Salem district and in Malabar, a distinct preference for the first two. The utmost we know of these woods is that they are all hard, close-grained woods; but, as to any other properties which give them their excellent charcoal-producing qualities, as yet we know nothing. The fact that they are all hard and comparatively slow-growing woods, suggests the conclusion that these are desirable properties probably on account of (1) the firmness of the carbonised product, and (2) the small percentage of ash which slow-growing woods generally leave on ignition.

Relation between annual yield and quality of charcoal.

If in general, slow-growing woods produce the best charcoal, we have the problem to solve of choosing between annual yield on the one hand and quality of product on the other. I do not, however, conclude from the mere fact of the native smelters preferring these hard woods, that only such wood gives the best kind of charcoal. As I have before stated, we are in comparative ignorance on the subject, because, as far as I know, no experiments have been made as to the amount of ash, calorific power, strength of product, or other properties, which are the test of a good charcoal. If it can be proved that *Casuarina,* and fast-growing trees in general, possess the characters of good charcoal-producers the course to pursue is obvious. To show this is the problem, and I am confident that it is one most easily and inexpensively solved. For this purpose I would suggest that a collection of the principal South Indian timbers be made, say four or five samples of each kind, selected from different localities, and that the ash, the calorific intensity and power, and quality of the charcoal produced be determined. The facts are of the simplest possible nature to ascertain, and the data so obtained will stand without question or modification as a permanent guide in the selection of a timber which combines, with a large annual yield, a suitable charcoal for smelting purposes, and, what must follow as a natural consequence, a good fuel for locomotive and domestic use.

Proposed collection of certain South Indian timbers for determination of ash, etc.

Styrian and American charcoal-burners and smelters.

Combined with this addition to our knowledge, it would be a decided advantage if an officer with a sufficient metallurgical training, could pay a short hot-weather visit to some continental or American iron-smelting locality, where charcoal is used (as in the Styrian process, which most nearly resembles that of the Salem steel-makers), for the purpose of examining the particulars of the processes, both of charcoal-burning and of iron- and steel-manufacture, and to collect either specimens or data of the fuel for comparison with the Indian timbers. A metallurgist, who has learnt his theory and practice in England, having paid exclusive attention to factories worked with coal alone, feels incompetent to give reliable advice on the nature of the timbers to be grown, or methods which are likely to be successful in iron-smelting with charcoal-fuel. Experiments on the native processes will be tedious, as well as unsatisfactory, and whilst to any one who has an elementary acquaintance with the principles and practice of metallurgy, the native methods of both charcoal-burning and iron-smelting are wasteful of material and uncertain in result, I would most decidedly not recommend the adoption of any improvement suggested from mere acquaintance with theoretical principles. A simple visit to a charcoal-burning and smelting locality will enable a metallurgist to offer the advice which will settle once

Improvement of native processes.

for all the question as to the possible development of the enormous iron-resources in this presidency; and considering the amount of money already lost in aiding unsuccessful companies, it will be a most profitable way of spending a hot season. In this, of course, I am taking for granted, as I believe it to be the case, that the use of coal for the Salem ores is quite out of the question. The only hope, as far as I can see, is the employment of charcoal of the right kind, and with the most economical process.

Warth's analyses of ashes.

Hitherto the only data of the above nature, as far as I can find, on Indian timbers are the instructive results obtained by Dr. H. Warth in the examination of the ash of twenty-six woods; but these are principally of more northerly growth.[1] Although Dr. Warth gives only the amount and composition of ash of these timbers, the results are sufficient to show the wide variation there is between the relative qualities of these timbers as fuels, and in a quadruple degree, as charcoal-fuels. *Bauhinia Vahli*, the *Maljhan*, gives for example an abnormal ash of 11·74 per cent., and its very slow-burning properties make it just a convenient log to inspire the story-telling fakír! The ash, of course, not only affects the rate of combustion, but, from the specific heat of the inorganic material, is a considerable source of loss in heat, besides, in iron-smelting, introducing bases which have a decided effect on the quality of the iron and steel produced.

Slow-burning timber.

Sir D. Brandis' proposal of *Casuarina* and *Eucalyptus* plantations.

In his exhaustive report on the Forest Administration in the Madras Presidency, Sir D. Brandis details the evidence which leads him to conclude that the forests may be developed greatly to the advantage of the iron-industry, but before cultivating, as he advises, the fast-growing *Casuarina* and blue-gum, I would suggest the precaution of ascertaining whether these, or what, trees are capable of producing a suitable charcoal for iron-manufacture; and, for this purpose, it is necessary, as Dr. Brandis reiterates in many places, to attach a competent metallurgist who has had practical acquaintance with charcoal iron-smelting, either to the Forest Department or to the Geological Survey in Madras. This might easily and inexpensively be brought about in the manner indicated above, and my remarks on Kanjamalai are, I hope, sufficient to show that we are by no means sufficiently acquainted with the mineral resources of Salem to allow of an unqualified condemnation of any attempt to develop its immense iron-deposits.

Dr. Brandis' proposal to attach a Metallurgist to the Forest Department or Geological Survey.

VII.—Conclusions on the questions affecting the development of the industry.

The conditions which will affect the possible development of the iron-manufacturing industry in the Salem district may be arranged under the following heads:—

(*1*) *Resources of iron-ore.*

[1] Manual of Natural Sciences for the use of students in the Forest School, Dehra Dun, Calcutta, 1886, pp. 184, 185.

(2) *Supply of auxiliary ores of—*
  (*a*) Chromium.
  (*b*) Manganese.
  (*c*) Titanium.
  (*d*) Aluminium.
  (*e*) Tungsten.
(3) *Fuel supply.*
(4) *Smelting methods.*
(5) *Bye-products.*
(6) *Market.*[1]

For the reasons detailed in the preceding pages I beg to submit the following conclusions and suggestions under these heads:—

(1) *Resources of iron-ore.*—These are without question undoubted in quantity, and I may say also in quality; but a statement of the exact amount of iron yielded by an average sample of ore I hope to embody in my final report, together with the results of a careful search for phosphorus, sulphur and other elements which have such a pronounced effect on the quality of the iron and, especially, of the steel produced.

(2) *Supply of accessory ores—*

(*a*) *Chromium.*—The great and increasing demand for this metal as an advantageous addition to steel has been indicated in a previous page (p. 140). I have recorded, also, my reasons for the probability of additional occurrences of chromite in the Salem district, and would suggest that a search for this mineral be instituted at the north-west base of Kanjamalai and in other localities which present the petrological characters already stated as favourable to the occurrence of this mineral.

(*b*) *Manganese.*—With regard to this mineral there is no definite evidence to offer as to its occurrence within the limits of this district, beyond the fact of its frequent association with, and sometimes in, iron-ores. Chemical examination of the specimens collected will throw some light on this question.

(*c*) *Titanium.*—Newbold's discovery of this metal in the iron-ores of Salem suggests a careful search for its minerals. It has been pointed out that the metallurgical advantages arising from the use of titaniferous iron-ore are as yet doubtful, but they seem to bear more on the conditions of smelting rather than any alloyed product (*vide* p. 139). They are used largely in Sweden and in Ontario with minerals of the same nature, and obtained from the same class of metamorphic rocks, as those of Salem.

(*d*) *Aluminium.*—The deposits of corundum have long been known. Should a cheaper method of manufacture be invented, or some natural source of power, like falling water, be employed with present methods, as recently suggested by Mr. A. Chatterton, the value of this metal, though questionable as an advantageous introduction to steel, is, for other purposes, undoubted. The very high price of aluminium and the demand which this useful metal is, from its exceptional

[1] The demand for iron is too well secured to call for remark on this head.

properties, bound to secure, make this point decidedly worth attention. I would call attention to Mr. Chatterton's scheme for utilising the great water-power of South India for the manufacture of aluminium, and at the same time suggest a careful survey of the valuable corundum-deposits of the districts of Salem, Coimbatore, and North Arcot, as well as Mysore; and that a further search for the minerals cryolite and bauxite be made. Lacroix's paper in Volume XXIV of the Records of the Geological Survey of India proves that we are as yet unacquainted with the variety of minerals in the crystalline rocks of Salem, and he has especially offered some suggestive points on the paragenesis of corundum.

(*c*) *Tungsten.*—This metal is occasionally used in steel to impart hardness to the alloy, the steel taking a fine damask According to Vosmaer it is often found in wootz. This is another point to be decided by chemical examination of the specimens.

With regard to the whole question of the alloying of iron with the metals referred to above, it may be remarked that the recent discoveries of Hadfield, Roberts-Austen, and others of the remarkable properties of iron-alloys indicate a probability of considerable development in this respect.

(3 *Fuel supply.*—As the supply of coal seems to be out of question, the fuel must be entirely charcoal: Under this head has been given a summary of our present knowledge concerning the kinds of timber preferable for the manufacture of charcoal for iron-smelting, and for ordinary fuel on the railway and in towns. I have also given reasons for suggesting the determination of the ash, calorific power and other properties of selected South Indian timbers as necessary preliminary data for carrying out Dr. Brandis' suggestion of increasing the yield by *Casuarina* and blue-gum plantations. The suggestion of Dr. Brandis to attach a metallurgist, having practical acquaintance w'th charcoal iron-smelting, to the Forest Department may, I believe, be most inexpensively carried out by deputing an officer for a few months only to the charcoal-burning and smelting localities of Styria or America, for the purpose of examining the processes of preparing the charcoal and smelting the ore in a manner which has proved to be commercially successful. Such an officer will be able to apply the experience of the charcoal-burners to the facts obtained in the laboratory as to the value of the different woods for iron-smelting, and to offer advice which ought to settle the question, once for all, of the practicability of (*a*) forest development, (*b*) charcoal-burning and its bye-products—pyroligneous acid and the results in general of dry, destructive distillation of wood, (*c*) improving, or replacing by European processes, the native methods of smelting, and (*d*) the utilisation of the accessory ores of chromium, manganese, titanium, aluminium, and tungsten.

(4) *Smelting methods.*—The present mode of native smelting is attended with an enormous waste of heat, ore and labour in the blast-producing. In estimating the furnace-charge by pure guess-work, there is not only a waste of material, but a highly detrimental uncertainty of result. Although the manufacture of wrought iron by the direct process is open to many drawbacks, it must be admitted that the use of charcoal, on account of its regular purity, removes one important objection. The manufacture of steel by the preliminary production of pig-iron in small

furnaces has been suggested by Dr. Warth, and, according to Mr. Heath, some such process was at one time employed by the natives; but none of the present pariah workers seem to be acquainted with the practice.

Without doubt the absurd blowing apparatus can be improved with advantage, and numerous other improvements suggest themselves to any one acquainted with metallurgy, but I would strongly urge the importance of not tampering with the present methods except under advice of a metallurgist who has seen something of charcoal iron-smelting in addition to the education which an English metallurgist receives in places where coal is the only fuel employed.

In mining and dressing the ore the native methods are even less economical than in the smelting. Because of their friability decomposed pieces of ore only are selected, and from these a large quantity of limonite and quartz has to be separated, whilst richer ore, on account of its superior hardness, is rejected.

Madras, February 29th, 1892.

On the Occurrence *of* Riebeckite *in* India, *by* THOMAS H. HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India.*

History of riebeckite.

In 1882 Professor T. G. Bonney, in a paper to the Royal Society describing a series of rock-specimens collected by Professor Bayley Balfour on the island of Socotra, referred to the occurrence in one of the granitoid rocks of a mineral which, whilst presenting many of the characters of members of the amphibole-group, he, apparently with some hesitation, referred to tourmaline, regarding it as pseudomorphous after hornblende.[1]

In 1888 the same author described "a peculiar variety of hornblende from Mynydd Mawr, Carnarvonshire," which in general appearance and in optical characters resembled the Socotra mineral.[2] He classed this mineral with the hornblende-group, and on account of a communication from Professor Sauer of Leipzig, who had isolated and analysed a similar mineral, referred it, apparently not without some misgivings, to arfvedsonite (*cf.* footnote, *op. cit.*, p. 106).

Independently Mr. A. Harker had been studying the Mynydd Mawr 'porphyry,' and had also described the peculiar blue mineral as hornblende.[3]

Professor A. Sauer of Leipzig noticed amongst a series of rocks collected by Dr. E. Riebeck, on the island of Socotra, the blue mineral previously mentioned by Professor Bonney. From its optical characters and from the chemical analysis of the isolated mineral, Sauer, independently of both Professor Bonney and Mr. Harker, referred it to the hornblende-group as a new variety under the name of *riebeckite*.[4]

It seems that, whilst this mineral in many respects resembles arfvedsonite, it differs in the fact that most of the iron entering into its composition exists in ferrous combinations,[5] and it appears from Rosenbusch's description,[6] that the axis of

[1] *Phil. Trans.*, vol. 174 (1883), p. 283, and pl. VII.
[2] *Min. Mag.*, vol. VIII, p. 105.
[3] *Geol. Mag.*, dec. III, vol. V (1888), p. 225.
[4] *Zeitschr. der Deutsch. geol. Gesell.*, vol. XL (1888), pp. 138-146.
[5] *Ibid.*, p. 143.
[6] *Ibid.*, pp. 143 and 144.

optical elasticity which makes an angle of 5° with the vertical crystallographic axis, c, is α and not γ, as is usual with the amphiboles. In this respect, as well as in the condition in which the iron exists, it resembles ægirine of the augite-group, and thus contributes to the completion of the parallelism between the amphiboles and the pyroxenes.

Since the publication of the above-mentioned researches, riebeckite has been recognised in a Corsican granulite by M. U. LeVerrier,[1] and in a rock from Colorado, which M. A. Lacroix would regard as an elæolite-syenite in which the quartz replaces nepheline[2]; in a micro-granite from Ailsa Craig, by Mr. J. J. H. Teall;[3] in eurite-pebbles found by Mr. P. F. Kendall in the glacial drift of the Isle of Man and on Moel-y-Tryfan by Professor Grenville A. J. Cole.[4]

The present note records the occurrence of this interesting mineral in India. The rock in which it occurs was discovered by Mr P. N. Bose as an intrusive boss in the slates of Daling age[5] between Song and Tikobu, Southern Sikkim.[6]

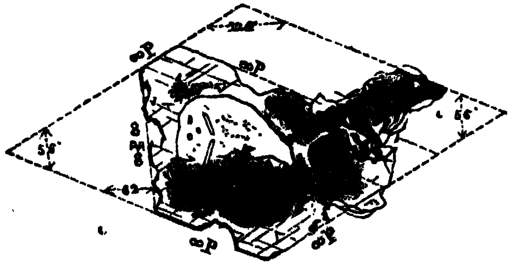
It is a compact, fine-grained rock, almost slate-grey in colour when fresh, but weathering to a pale brown on exposure. Its specific gravity is 2·78.

Under the microscope thin sections exhibit quartz, orthoclase, microcline, oligoclase, biotite, riebeckite, sphene, zircon, magnetite, titanoferrite, and, perhaps, apatite.

Optical properties.

The riebeckite occurs in crystals seldom exceeding ·034 inch (·08 cm.) in length and, more rarely, as much in diameter. From the way in which they have been interrupted in their growth by neighbouring quartz- and felspar-crystals, they rarely present recognisable idiomorphic outlines, but frequently exhibit a feeble attempt at ophitic development. The optical characters and the characteristic cleavage of amphibole (see figure) demonstrate satisfactorily the identity of this mineral with Sauer's riebeckite. The pleochroism is—

α, indigo-blue.
$\beta(=b)$, deep blue.
γ, yellowish green.



Horizontal Section of Riebeckite.

[1] *Comptes Rendus*, vol. CIX (1889), p. 38.
[2] *Ibid.*, vol. CIX (1889), p. 39.
[3] *Min. Mag.*, vol. IX (1891), p. 219.
[4] *Ibid.*, vol. IX (1891), p. 222.
[5] The name applied by Mr. F. R. Mallet to a group of sub-metamorphic rocks in the Darjeeling district. (*Mem., Geol. Surv., Ind.*, vol XI (1874), p. 12).
[6] Bose: *Rec., Geol. Surv., Ind.*, vol. XXIV (1891), p. 222.

The angle between the vertical crystallographic axis *c* and *a* gave 9° as an average of twelve measurements varying from 7° 30' to 10°,—the intense absorption making the measurement of extinction a matter of considerable difficulty. This result gives a wider angle than that obtained by Sauer, who found that in the Socotra mineral the extinction-angle was about 3—4°, whilst Rosenbusch gave it as 5°.[1]

Inclusions in riebeckite.

Almost every riebeckite crystal is opaque in the centre. This is sometimes due to a nucleus of magnetite around which the mineral has grown; but occasionally this core is seen to be almost white by reflected light, and I could not decide whether it was due to original opaque inclusions or to the results of secondary alteration. The fragmentary state of the crystals and the large quantities of these opaque inclusions would make a chemical analysis of little value, even should it be possible to separate crystals so small from other heavy ferro-magnesian silicates in the rock. Besides the larger crystals, minute lath-shaped and rod-like crystals presenting similar optical properties occur in the matrix, and are presumably also riebeckite-crystals.

The remaining constituents already enumerated make, with riebeckite, a rock which might be classed as a *granitite.*

As in all cases previously recorded, riebeckite appears as a constituent of an igneous rock, and accompanied also by zircon and sphene. The mineral recalls in some respects the beautiful crystals of glaucophane, which seem to occur, on the contrary, only as a constituent of undoubted metamorphic rocks.

Paragenesis of riebeckite.

In the granulite described by M. Le Verrier from Corsica, riebeckite occurs associated with the zircon and titanium-bearing mica, astrophyllite; in the Colorado rock described by M. Lacroix, it is associated with astrophyllite and pyrochlore—a columbate of lime and cerium. In this rock, found by Mr. Bose, and in nearly all cases hitherto recorded, zircon- and titanium-bearing minerals seem to accompany riebeckite. This association with the so-called rare metals (whose habits are daily becoming more familiar to mineralogists and chemists) seems to be a point worthy of attention: it seems likely that before long a mineral, more so than a man, will be known by the company it keeps, and it will please the curious to discover the qualifications by which an *entrée* is obtained to the select circles of Brevig and Friederichsvärn in Norway, Miask in the Urals, and, soon we shall be able to say, Salem in Madras.

Coal *on the* Great Tenasserim River, Mergui District, Lower Burma, *by* T. W. H. HUGHES, *Superintendent, Geological Survey of India.*

The announcement of the discovery of coal on the Great Tenasserim River prompts me to point out that many years ago, and soon after our occupation of the Siamese districts which we had wrested from the Burmans, the existence of coal at various spots on the Great Tenasserim River was made known.

[1] Sauer: *op cit.*, pp. 143 and 144.

Amongst the first explorers of the country, the chief ones were Dr. Holfer in 1838, Captain G. B. Tremenheere in 1841, and Dr. Oldham in 1855. The latter gives a list of places where coal occurred in the Great Tenasserim valley :—

Heinlap,	Hinlat,
Kanmapying,	Kaw-ma-pyin,
Pawort,	Pawút,
Thatay-hkhyoung,	Kyauk-mi-thwe,

and he describes the coal-seam that was worked experimentally in 1843, and which is alluded to as the Thatay-hkhyoung coal, Kyauk-mi-thwe coal or Thendaw coal, in the various publications and official papers referring to it.

The discovery of coal, therefore, this year is a re-opening, and is only so far new, in that coal has been proved at another point.

It was deemed advisable, while carrying on prospecting operations for minerals generally in the Mergui district, to furbish our information while the means for doing so were at hand,—and perhaps by calling attention once again to the value of the Tenasserim coal-field, afford an opportunity to mining venturers of satisfying their ruling taste.

The coal tested by our party, crops out in the Hti-phan-ko stream, a tributary on the right bank of the Great Tenasserim River, 24 miles due east of the town of Mergui. Two pits were sunk on the seam by Mr. Alexander Primrose, who had charge of the prospecting operations, and the section is, descending—

Surface soil, etc.—

Coal	0′	10″
Shale	2′	0″
Coal	2′	3″
Shale	3′	0″
Coal	4′	6″
Total seam	12	7
" coal	7	7

The angle of dip is high, being as much as 32°. Direction, slightly S. of E.

Analyses of three samples, two (A and B) from the upper 2′ 3″ layer, and one (C) from the bottom 4′ 6″ bed, have been made by Mr. T. H. Holland, Curator of the Geological Museum, and the results are :—

Specimen "A."		*Specimen "B."*	*Specimen "C."*
Moisture	15·20	10·80	11·34
Volatile matter	30·08	27·36	36·40
Fixed carbon	30·86	42·52	43·27
Ash	23·86	19·32	8·99
	100·00	100·00	100·00
Does not cake.		Does not cake.	Does not cake.
Ash, reddish brown.		Ash, reddish brown.	Ash, reddish brown.

SPECIMEN A.—Fissile parallel to the planes of stratification, the cleavage-planes being dull, possibly from films of argillaceous material. Fracture across the bedding planes, rather uneven, and, where carbonaceous matter is more concentrated, feebly conchoidal; these surfaces exhibit a shining lustre.

SPECIMEN B.—Similar physical characters to A.

SPECIMEN C.—Breaks in all directions with a conchoidal fracture, the surfaces invariably exhibiting a shining lustre. None of the specimens soil the fingers, in this respect differing from most of the Indian coals of younger age. "

The bottom coal (specimen C) is the one I would more particularly call attention to, as it is a hard jetty variety, well fitted to stand the wear and tear of transport, and contains very little pyrites.

Trials were made to test its efficiency in the Government steam launch *Mergui*, and it gave satisfactory results, there being no difficulty with untrained firemen in raising and keeping 95℔ of steam on a long course. There was a little clinker.

The commercial value of the Tenasserim field depends, as I am aware, upon questions other than those of the mere quality or quantity of the coal, but it is a strong point in its favour when the coal is above the average Indian standard, as this is.

The locality in which it occurs is unfortunately situated for labour transport and shipment, disabilities representing a less profit to lessees. But I think the following estimate will cover the charges for one ton of coal at the pit side, on an out-put of 10,000 tons a year:—

	R	*a.*	*p.*
Labour	2	8	0
Stores	1	0	0
Establishment and supervision	1	0	0
Haulage and contingencies	1	0	0
Royalty	0	4	0
	R 5	12	0

Transport to Mergui, R2-0-0.

A market other than the local one must be found. Two exist, in Rangoon and Penang, in both of which there would be a large sale for a good steam coal at low rates.

What I have written is simply to recall the fact that there is coal on the Great Tenasserim River, and it rests with those who may be inclined to embark in coal-mining to make such personal investigations as will satisfy themselves that the prospects of success are promising or otherwise.

The quantity of coal is abundant; and so soon as the map prepared this season by the Topographical Survey is issued, the proximate boundaries of the field will be marked, and a fuller paper with a coloured map will be published.

1st July, 1892. T. W. H. HUGHES.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 12.—Ending 31st July 1892.

Director's Office, Calcutta, 31st July 1892.

The Director, Dr. W. King, having taken privilege leave from the 24th of June last, Mr. T. W. H. Hughes has been appointed to officiate during the Director's absence.

In the present number of the Records Mr. Hughes has given an account of the occurrence of coal on the Great Tenasserim River, Mergui district, South Burma.

Mr. Griesbach and Dr. Diener left Calcutta on the 12th of May and were joined by Mr. Middlemiss at Naini Tal. The party proceeded *viâ* Almorah for the purpose of working out the palæontology and stratigraphy of the triassic rocks in the Central Himálayas.

Mr. LaTouche has made a report on the oil-springs near Moghal Kot in the Shirani country, with a description of the stratigraphical characters of the oil-bearing and associated rocks. Specimens of the oil collected at two points of outflow have been examined in the laboratory by Mr. Holland. One of the samples (A) exhibited certain chemical characters markedly like those of the specimen collected by Mr. Oldham two years ago, but the latter had lost its more volatile hydrocarbons by exposure in a shallow pool. By subjecting the former to artificial exposure, in imitation of the natural conditions, the volatile naphthas disappeared, and the residue gave a flashing point, specific gravity and fractional distillation strikingly near those of Mr. Oldham's specimen. The chemical results confirm also the opinion expressed by Dr. Warden in 1890 that "a large supply of a natural oil of this quality would simply drive all foreign oils out of the market." But Mr. LaTouche confirms the statement previously made by Mr. Oldham as to the limited supply of the oil, and in his report on the subject, which will be published in the next part of the Records, he makes certain suggestions for the purpose of obtaining a larger flow than that now obtainable at the surface.

Mr. Mallet, late Superintendent in this Department, shows his continued interest in Indian mineralogy by generously following up his translation of Lacroix's petrological researches on certain South Indian and Cinghalese rocks, with an interesting contribution clearing up the difficulties with regard to the locality of the mineral *tscheffkinite* (*vide* p. 123). The occurrence of this comparatively rare mineral on Kanjamalai in the Salem district, interestingly coincides with Mr. Holland's reference to the hypersthene- and olivine-bearing ultra-basic and other igneous rocks which have disturbed the rich iron-ore beds on the north-western slopes of the

same hill. These facts, together with the petrological work of M. Lacroix published in the last volume, lend some support to the expectation that Salem district will some day prove as rich in mineral variety as the natural museums of Norway and the Urals.

Amongst the features of interest noticed by Mr. Datta in his examination of the Sagaing district in Burma may be mentioned the occurrence of nodular iron-pyrites in sandstones, which the natives of the district formerly employed as a source of sulphur for the manufacture of their gunpowder. Mr. Datta is preparing a report on his work in this and in the Pakokku and Thayetmyo districts.

The nodules collected near Utatur in the Trichinopoly district by Dr. Warth contain, as he suggested, large proportions of phosphoric acid. Specimens analysed in the laboratory yielded on an average nearly 60 per cent. of phosphate of lime. Although the value of phosphates has lately been considerably depreciated on account of the finds in Algeria and Florida, the Trichinopoly deposit ought to prove of service on the southern tea and coffee plantations when converted into superphosphate; and there seems no reason why sulphuric acid should not be manufactured in India for such a purpose.

List of Reports and Papers sent into the Office for publication or record during May, June and July 1892.

Author.	Subject.	Disposal.
THEO. W. H. HUGHES	Coal on the Great Tenasserim River, Mergui district, Lower Burma.	Appear in the current Records, Geological Survey of India.
C. L. GRIESBACH	Geological sketch of the country north of Bhamo.	
FITZ. NOETLING	Preliminary Report on the economic resources of the Amber and Jade Mines area in Upper Burma.	
T. H. HOLLAND	Preliminary Report on the Iron-ores and Iron-industries of the Salem district.	
T. H. HOLLAND	On the occurrence of Riebeckite in India.	
T. H. HOLLAND	The Iron-ores and Iron-industries of the southern districts, Madras Presidency.	To appear as a preliminary hand-book for Imperial Institute.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June and July 1892.

Substance.	For whom.	Result.
Three specimens of phosphatic nodules from Utatur, Perambular taluq, Trichinopoly district.	Dr. H. WARTH, Officiating Superintendent, Government Central Museum, Madras.	Specimen "A"— Quantity received 12 lb. Contains 23·54 % phosphoric anhydride (P_2O_5). Specimen "B"— Quantity received 1¾ oz. Contains 30·9 % phosphoric anhydride (P_2O_5). Specimen "C"— Quantity received 9¼ oz. Contains 26·12 % phosphoric anhydride (P_2O_5).
One specimen of quartz .	OCTAVIUS STEEL & Co, Calcutta.	Assayed for gold and silver.
One specimen of graphite	STEEL BROS. & Co., Ld., Rangoon.	Carbon determined.
One specimen of "earth for analysis" from His Highness the Amir of Afghanistan.	WALSH LOVETT & Co., Calcutta.	=Lignite. (Peat passing into lignite, with roots of plants and a large number of fresh-water shells.)
One specimen of galena with quartz.	F. W. HEILGERS & Co., Calcutta.	Assayed for lead and silver.
One specimen of quartz, "No. 16."	BARRY & Co., Calcutta .	Assayed for gold and silver.
One specimen of iron pyrites with quartz from Nantyok, Henzai, Tavoy district, Burma, for gold.	P. N. BOSE, Geological Survey of India.	Contains no gold.
Two specimens of "quartz"	F. W. HEILGERS & Co., Calcutta.	=Talc-schist with pyrites. Assayed for gold and silver.
Three specimens of coal, from Kaw-ma-pyn, Great Tenasserim valley, Burma.	T. W. HUGHES, Geological Survey of India.	Specimen "A" (Upper seam)— Quantity received 1¼ lb. Moisture . . . 15·20 Volatile matter . . 30·08 Fixed carbon . . 30·86 Ash . . . 23·86 100·00 Does not cake. Ash—reddish brown. Specific gravity, 1·47.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July, 1892 —continued

Substance.	For whom.	Result.
		Specimen " B " (Upper seam)— Quantity received 2lb. Moisture . . . 10·80 Volatile matter . . 27·36 Fixed carbon . . . 42·52 Ash . . . 19·32 100·00 Does not cake. Ash—dark reddish brown. Specific gravity 1·40. Specimen " C " (Lower seam)— Quantity received 1½lb. Moisture . . . 11·34 Volatile matter . . 36·40 Fixed carbon . . 43·27 Ash . . . . 8·99 10·000 Sinters slightly. Ash—reddish brwon.
Two specimens of quartz, Nos. 2 and 3, from the Kedanak mines, Mount Ophir, Johore.	BARRY & Co., Calcutta .	Assayed for gold and silver.
One specimen from the Dundot colliery.	W. B. D. EDWARDS, Geological Survey of India.	Clay.
Two specimens from Nantyok, Henzai, Tavoy district, Burma.	P. N. BOSE, Geological Survey of India.	Pyrites with sulphate of iron efflorescence. Mispickel.
Two specimens from Dehra Doon, N.-W. Provinces.	W. POULTER, Mussoorie	No. I.—Fine powder composed of clay, minute sand grains, and powdered pyrites. No. II.—Sand: quartz, gralar, mica hornblende and pyrite.
One specimen from Baluchistan.	Executive Engineer, Public Works department (Zhob division), Fort Sandeman.	Iron pyrites.
One specimen from Doddancombai forest, Satyamangalam taluq, Coimbatore.	District Forest Officer, Coimbatore.	Magnetite.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July, 1892 —concluded.

Substance.	For whom.	Result.
One specimen . .	J. JARBO, Sub-Divisional Officer, Bandarban, Chittagong Hill Tracts.	Sulphate of alumina and sulphate of iron, with traces of lime.
One specimen . .	MACTAVISH & Co., Calcutta.	Bitumen (asphalt).
	Bengal Coal Company, Calcutta.	Coal. Specific gravity, 1·38.

Notification by the Government of India during the months of May, June, and July 1892, published in the "Gazette of India," Part I.—Leave.

Department.	Number of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	Remarks.
Revenue and Agricultural Department.	$\frac{1070}{120}$, Surveys, dated 31st May 1892.	WILLIAM KING	Privilege.	25th June 1892.	...	

Notifications by the Government of India during the months of May, June and July 1892, published in the "Gazette of India," Part I. —Appointment, Confirmation, Promotion, Reversion and Retirement.

Department.	Number of order and date.	Name of officer.	From	To	Nature of appointment, etc.	With effect from	Remarks.
Revenue and Agricultural Department.	$\frac{1072}{120}$, Surveys, dated 31st May 1892.	Theo. W. H. Hughes.	Superintendent.	Officiating Director.	Acting, temporary.	25th June 1892.	
Ditto . .	$\frac{1465}{8}$, Surveys, dated 14th July 1892.	H. B. W. Garrick.	Artist .	...	Substantive.	1st July 1891.	

Annual Increments to graded Officers sanctioned by the Government of India during May, June and July 1892.

Name of officer.	From	To	With effect from	No. and date of sanction.	Remarks.
	R	R			
R. D. OLDHAM	850	900	1st May 1892.	Revenue and Agricultural Department, No. $\frac{1351}{140}$, Surveys, dated 1st July 1892.	
W. B. D. EDWARDS	350	380	6th June 1892.	Revenue and Agricultural Department, No. $\frac{1456}{147}$, Surveys, dated 14th July 1892.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph office.
T. W. H. HUGHES	Calcutta	Calcutta.
C. L. GRIESBACH	Almora, N. W. P.	Almora.
R. D. OLDHAM	Calcutta	Calcutta.
P. N. BOSE	Do.	Do.
T. H. D. LATOUCHE	Kulu	Kulu.
C. S. MIDDLEMISS	Almora, N. W. P.	Almora.
W. B. D. EDWARDS	Murree	Murree.
P. N. DATTA	Calcutta	Calcutta.
F. NOETLING	Mandalay	Mandalay.
HIRA LAL	Dakha	Ludhiana.
KISHEN SINGH	Mandra	Mandra.

MEMO.

The Geological Sketch Map of Sikkim, accompanying this issue, is referred to in Article 3, published in the Records of the Geological Survey of India, Volume XXIV, Part 4.

ERRATA.

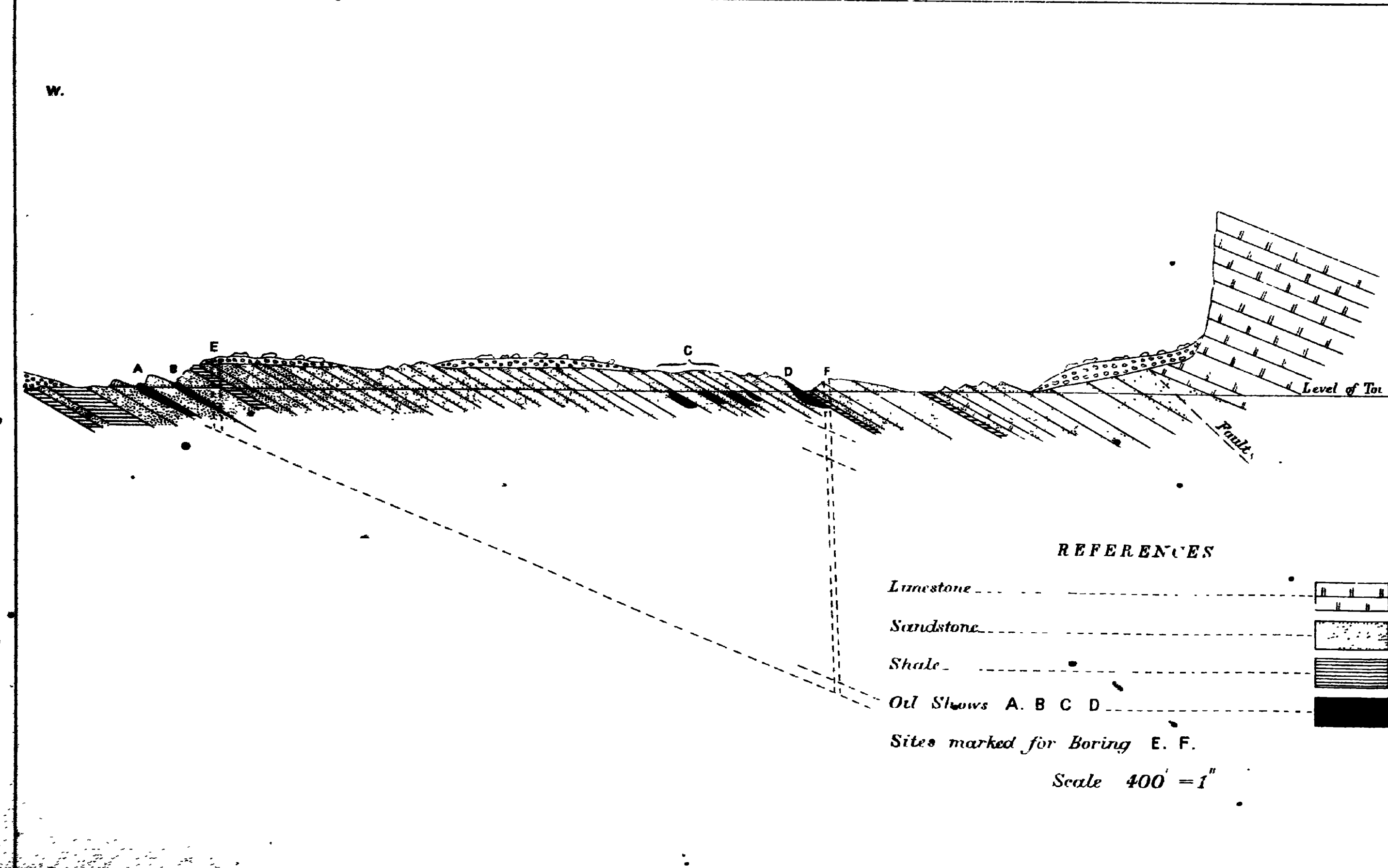
RECORDS, GEOLOGICAL SURVEY OF INDIA, Vol. XXV, pages 123-127.

Page.	Line.	For	Read
124-5-6	...	Langier	Laugier.
124	3 from bottom	Ile	I'lle.
125	24	Kantiamalée . . .	Kantiamal'é
125	5 from bottom	"I"	"J"
126	21	earths and sesquioxides .	earths sesquioxide.

ERRATA.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA, VOL. XXV, PART 2.

On page 61, line 19 from below, read: *skirting*.
" " 62, " at bottom, read: *watershed.*
" " 63, " 12 from below, instead of passs, read: *pass.*
" " " " 9 from below, insert a *comma* after Kábul province.
" " 65, " 8 from below, for Mari, read: *Marine.*
" " " " 2 from below, for Baluchistán, read: *Sind.*
" " 68, " 17 from above, for dislocation, read: *dislocations.*
" " 75, " 17 from above, for Tangi Rájan, read: *Tangi Rojan.*
" " " " 22 from above, leave out the *comma* after: it may be.
" " " " 14 from below, for: Kóh-i-Sultán Áhméd Kabír, read: *Kóh-i-Sultán Ahmed Kabír.*
" " 80, " 11 from above, for page 78, read: *page 69.*
" " 83, " 2 from below, for nummulites, read: *nummulitics.*
" " 84, " 11 from above, for no, read: *not.*
" " " " 14 from above, insert *a* after them.
" " " " 17 from below, for most, read: *both.*
" " " " 13 from below, for predominate, read: *predominates.*
" " " " 11 from below, for page 83, read: *page 81.*
" " 86, " 11 from below, for hence, read: *thence.*
" " " " 8 from below, for Khank, read: *Khanki.*
" " 87, " 14 from above, for sapposition, read: *supposition.*
" " 89, " 7 from below, leave out: *lower.*
" " 92, " 8 from above, for: of the existence, read: *on the supposed existence.*
" " " " 26 from above, for Kam Silmán, read: *Kam Shilmán.*
" " 95, " 14 from below, omit the *comma* after road.
" " 97, leave out the second foot-note at bottom of the page.
" " 103, " 12 from above, leave out: *of.*
" " " " 14 from above, from *north-west to south-east.*
" " 105, " 16 from above, for dislocation, read: *dislocations.*
" " " " 18 from above, for palæozoic, read *palæozoics.*
" " 10?, " 16 from above for certainly, read: *certainty.*



Lithographed & Printed at Geological Survey Office

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1892. [Nov.

Report *on the* Oil Springs *at* Moghal Kot *in the* Shirani Hills, *by* TOM D. LATOUCHE, B.A., *Deputy Superintendent, Geological Survey of India* (With 2 plates.)

Introductory remarks.

The oil springs in the vicinity of Moghal Kot, a village in the Shirani Hills lying about 12 miles to the south-east of the Takht-i-Suleiman, appear to have first been brought to notice about the end of the year 1889, when samples of the oil, purporting to be from this locality, were sent down to Calcutta and examined both in the laboratory of the Geological Survey and by Dr. Warden, Chemical Examiner to the Bengal Government. The first sample examined by Dr. Warden was, according to his conclusions, "not a crude, but a commercial kerosine oil of Russian origin." Subsequently, Dr. Warden reported on a sample, procured by the Deputy Commissioner of Dera Ismail Khan from this locality, which he found to be of excellent quality. Another specimeen collected by Mr. Oldham in 1891 and examined in the laboratory of the Geological Survey by Mr. Holland, although inferior in quality to the sample examined by Dr. Warden, was found to contain large quantities of liquid hydrocarbons.[1] The doubts attending the stated existence of the oil, if not of its quality, having been removed, it remained to discover what the chances were of its being procurable in sufficient quantites to render it commercially valuable, a question which Mr. Oldham was unable to decide, owing to the hurried manner in which he was compelled by ill-health to carry out his observations. This, therefore, is the point I have mainly kept in view during my recent exploration of the country.

Position of the springs.

About a mile above the village of Moghal Kot, the river Toi[2] traverses a lofty ridge, running north and south, the greater portion of which is composed of hard fine-grained quartzose sandstones, overlaid by a thick band of massive limestone. Through these rocks the river has cut a deep narrow gorge, about half a mile in length; the oil springs are found in this

[1] *Records, Geol. Surv.* Vol., XXIV, pt. 2, page 86.

[2] This river is erroneously called the Cholkhel Dhana in the map of 1884; *Dhana* is the name locally given to the gorges cut by the streams through the Takht-i-Suleiman range, and does not apply to the whole of the river valley. The minor gorges through the belts of hard rock beneath the main range are called *Tiri*, as Tiri Chuakhel, Tiri Khidarzai, etc., while those through the outer belt of hard rocks at the edge of the hills are called *Zam*, as Zam Chandwan, Zam Draband, etc.

gorge, and their position is indicated in the plan of it annexed to this report. The most copious discharge takes place close to the base of the quartzose sandstone (at the points marked A and B on the plan), but oil also oozes from them at the points C and D, about midway between the base and summit. In all cases the discharge takes place close to the water's edge. At C the rocks are merely saturated with the oil, and at D it occurs in the form of small globules, floating on the water collecting in shallow holes in the shingle on the river bank. The flow was so slight at these points that no good samples of the oil could be collected for examination. At A and B, however, the oil gathers in shallow holes dug in the sand at the level of the water in the river, and from these spots I obtained good samples which have been sent down to Calcutta to be examined in the laboratory of the Geological Survey. The actual points of outflow seem to have been determined by the existence of beds of shale intercalated with the sandstones; the oil apparently creeping up along the bedding planes, beneath these shale bands until it reaches the surface.

Quality of the oil.

As it issues from the rock the oil is limpid, slightly yellow in colour and opalescent. It has an unmistakable odour of kerosine, which can be perceived at several paces from the spots where it escapes from the rock; and without any refining whatever it gives a brilliant light when burnt in an ordinary lamp. The sample obtained from A seemed to me to be rather more oily in character than that from B, and I at first thought that the difference between the sample examined by Dr. Warden and that collected by Mr. Oldham might have been due to their having been collected from these different spots, but Mr. Holland has since informed me that the samples from A and B are essentially the same, the slight difference being accounted for by an exposure of the sample from A for a short while.

No gas observed.

No traces of gas were observed to accompany the discharge of oil at any of the spots where it issues from the ground.

Rate of discharge of the oil.

The rate of discharge of the oil is exceedingly slow. I had one of the shallow holes in the sand at each of the points A and B cleaned out, and the time occupied in filling a quart bottle with the oil was observed. Making a rough calculation from this I find that one of the holes at A would yield a gallon of oil in 4½ hours, while it would take 14 hours to collect the same amount at B. The discharge might possibly be increased to a slight extent by clearing away the sand, but it was impracticable for me to test this, as it would have entailed the construction of a dam to keep out the river water. Under the most favourable circumstances I do not think that the flow would exceed 10 gallons a day from both these places.

Occurrence of oil extremely local, no traces of it found in extension of the sandstone band to the north.

The ridge of hard rocks in which the oil of Moghal Kot occurs extends for about 30 miles to the north of the Toi river, and is traversed by other streams, the principal being the Shingao, which breaks through it above the village of Karam; the southern branch of the Lohara, or Drazund river, breaking through the ridge immediately beneath the Takht-i-Suleiman itself at Raghasur; and the northern branch of the same river, which flows round the north end of the Takht, through the gorge called the "Gut," and issues at Powa Sur, a small village above Murgu. In each of these cases the section exposed is identical with that in the

gorge of the Toi, yet in neither of them did I succeed in detecting the slightest trace of oil. Its occurrence therefore in appreciable quantity is extremely local, and the band of sandstone in which it occurs cannot be considered as in any sense a generally oil-bearing stratum, that is, a stratum in which we should be likely to find an accumulation of oil at any point, even though the conditions at that point were otherwise favourable.

Peculiar structure of rocks in Tiri Chuakhel facilitating escape of oil.

It is true that the escape of the oil in the gorge above Moghal Kot is facilitated by the peculiar structure of the rocks in that locality. Along the line of the river-bed there is a decided twist in the strike of the rocks, the beds to the south of it dipping east or within a few degrees of east, while on the north bank the dip is steadily north-east. The effect of this twist, combined with the dip of the rocks, from 30 to 40 degrees has been to form a kind of inverted trough, rather steeply inclined to the east, along the axis of which the flow of oil has been concentrated. This structure, however, although it would account for a larger outflow at this point than at any other if the sandstones were everywhere oil-bearing, will not account for the entire absence of oil at the other points where the ridge is cut through. The conclusion I have drawn is that there is no real connection between the peculiar structure of the rocks and the occurrence of the oil at this particular locality, that it is, in fact, a mere coincidence.

Before discussing the question as to whether there are any places in the Shirani Hills where an accumulation of oil may have been formed sufficiently near the surface to be reached by borings of a reasonable depth it will be well to set forth briefly the general considerations, underlying the problem.

General conditions under which accumulations of oil in workable quantities are formed.

Although the conditions under which petroleum is originally formed by natural processes in the bosom of the earth are not yet fully understood none of the theories that have been from time to time put forward to account for its production, whether by distillation from coal seams or other organic matter, or by chemical combination in one form or another, being entirely satisfactory, yet in determining the probability of its occurrence in large quantities in any locality where it is known to exist we are not concerned with any of these theories, for it is fairly certain that the oil is seldom or never indigenous in the strata from which it is obtained by borings, but that it has been introduced into them by percolation from regions far below, so deeply seated that they have never been, nor are likely to be, reached by borings from the surface. We have therefore only to deal with the conditions under which the oil may collect at various points in porous strata, in such a manner that it is stored as in a reservoir, until a way is opened for its escape to the surface by borings or otherwise. Such conditions, it seems to be now universally admitted, are most favourable where the strata are thrown into gentler undulations, anticlinals and synclinals, so disposed that the oil rising from below is held under the crowns of the anticlinals, presupposing that the porous strata which afford storage for the oil are covered by impervious beds, which prevent its rising further towards the surface. Conditions so favourable as these are, however, realised in few cases, the oilfields of Pennsylvania, Baku, and Burma being the most notable instances; at the same time accumulations of oil in workable quantities are not unknown in localities where the strata are more highly disturbed, *e.g.*, in Galicia; but in such places the means of escape naturally afforded to the oil are easier than in the oilfields abovementioned, and therefore, although the surface indications may be even more

conspicuous than they are in those fields, the accumulations of oil are never so great. A full discussion of the conditions under which oil is worked in such disturbed regions, with special reference to those generally obtaining in India, will be found in Mr. Medlicott's "Note on the occurrence of Petroleum in India,"[1] where sections are given showing the disposition of the strata in the highly disturbed oil-bearing regions of Galicia.[2]

Conditions found to exist in the Shirani Hills.

Such being the considerations to be kept in view when estimating the probabilities of oil occurring in any district known to be oil-bearing, in sufficient quantities to be profitably worked, it remained to be seen to what extent they would apply in the Shirani Hills. In determining this point we have only the outcrops of the rocks overlying the oil-bearing rocks to guide us, and the evidence afforded by these is, I regret to say, distinctly unfavourable. In passing down the Toi river from the oil-springs we obtain a very clear section of these rocks. The group of hard quartzose sandstones, about 1,000 feet thick, in which the oil occurs, is overlaid by a band of hard massive limestone, about 300 feet thick, the whole dipping in an easterly direction at between 30 and 40 degrees. Following on the limestone, and dipping in the same direction, with some minor folds, a great series of shales with sandstone bands of various thickness is found. The total thickness of this group is probably not less than 10,000 feet and the strata composing it are inclined to the horizon at about the same angle as the limestone beneath. Above this group comes a series of beds containing gypsum bands at the base, overlaid by bands of nummulitic limestone and fossiliferous shales. These also have an easterly dip though not so high as in the beds beneath, as far as Parwara village, below which there is a well-marked synclinal. On the eastern side of this the beds are repeated, dipping west, as far as the horizon of the gypsum bands, which are exposed in the hill on which Domanda outpost stands. Here there is a sharply compressed anticlinal fold, upon the denuded edges of which sandstones of Siwalik age have been deposited. This is the anticlinal noticed by Mr. Oldham in his "Preliminary report on the oil locality near Moghal Kot"[3] under which he suggests "there is probably a considerable accumulation of oil." The lowest beds exposed, however, on the crest of the anticlinal are the shales immediately underlying the gypsum bands, which, as we have seen, are the topmost members of a group of rocks 10,000 feet thick. It would in all probability therefore be necessary to bore through the whole thickness of that group, and 300 feet or so of hard limestone beneath, before reaching the sandstones in which oil might possibly occur. It need hardly be said that such an undertaking would be utterly absurd. Moreover this anticlinal is not an open undulation, like those beneath which the most productive oil-bearing strata are found; indeed, it bears evidence of so much crushing, that it would be difficult to account for the non-existence of any oil shows along its crest, supposing that the rocks beneath did contain oil. To the north of the Toi this anticlinal has been traced as far as the Lohara or Drazand river presenting everywhere the same features. Thus, although it offers the nearest approach among these hills to the conditions found to be favourable in other oil-producing regions, yet

[1] *Records, Geological Survey*, Vol. XIX, pt. 4, p. 185.

[2] See also a paper by Mr. R. D. Oldham, "Memorandum on the mode of occurrence of Petroleum," published in 1891.

[3] *Records, Geological Survey*, Vol. XXIV, pt. 2 p.

these conditions are so far different as to render it unprofitable to undertake operations on so large a scale as would be necessary to determine the existence of oil along that line.

Possibility of increasing the present outflow by means of wells or borings.

Such being the case it remains to be considered whether it would not be possible to increase the discharge of oil in the neighbourhood of the present springs by means of wells or borings. A well might be sunk at the point E on the plan, which would meet the beds, from which the oil at A and B issues at a depth of about 130 feet. Short galleries, driven in either direction along the strike of the beds from the bottom of this well, would afford a more ready means of escape for the oil than now exists, and such a plan would have the advantage of excluding the water from the river, which under present conditions filters in through the sand covering the outcrop, and becomes mixed with the oil. But I doubt whether the outflow would be increased to any material extent by such means, for the oil at so slight a depth would not be under much greater pressure than at the surface.

Another plan might be tried, though it would doubtless be more expensive, and that is to sink a deep boring through the whole of the strata known to be oil-bearing, that is from a point to the east of D on the plan, say at F.[1] Such a boring would have to be at least 760 feet deep in order to reach the lowest oil beds, and should be of large diameter, say 6 inches. I do not anticipate much difficulty in boring such a hole through the sandstones, as in all probability they are much softer in the interior than at the surface. On reaching the lowest oil beds, unless the flow of oil under the increased pressure was found to be satisfactory, a powerful charge of dynamite, or "torpedo," should be exploded at the bottom of the hole, so as to shatter the rock in its vicinity. This might possibly largely increase the flow of oil and the experiment might be worth trying at least. The difficulty would be to get the machinery required for boring a hole of such a size to the spot. There is an unlimited supply of water power, which might be made use of instead of steam, as the river at this point has a considerable fall (about 50 feet measured from the head of the gorge), and even at the time of my visit, in March 1892, after twelve months of practically rainless weather, there was a sufficient volume of water in it for all purposes. Every part of the machinery would have to be brought on camels from the edge of the hills, a distance of about 25 miles, as the only way of reaching the place is along the stony bed of the Toi river, where it would be impossible to use wheeled vehicles.

Second Note *on* Mineral Oil *from the* Suleiman Hills, *by* THOMAS H. HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India.*

Last year (1891) I published an account of a chemical examination of crude mineral oil collected by Mr. R. D. Oldham above Moghal Kot in the Suleiman Hills, Sheráni country.[2] From the comparatively high specific gravity and flashing

[1] The two points E and F were chosen so that they lie above flood-level. They are marked on the ground by stone cairns.

[2] On Mineral Oil from the Suleiman Hills." *Records, Geological Survey of India,* Vol. XXIV (1891), pp. 84—97.

point, and from the results of fractional distillation, indicating a predominance of the heavier hydrocarbons, I concluded that, compared with other samples previously obtained from the same district, the specimen sent by Mr. Oldham must be considered to be decidedly inferior in quality. Mr. T. H. D. LaTouche has recently sent two samples collected by himself at the same locality (one and a half miles above Moghal Kot, Sheráni country), and a chemical examination of these samples proves them to be extremely valuable for illuminating purposes, thus confirming the result obtained by Dr. Warden in September 1890, and at the same time explaining, as will be pointed out below, the apparent inferiority of Mr. Oldham's specimen.

The following is the result of an examination of the two samples collected near Moghal Kot by Mr. La Touche :—

Specimen A.

This sample was a deep yellow, mobile liquid, slightly turbid through the presence of disseminated bituminous particles, and with a large quantity of water at the bottom of each bottle. Cleared of its dirt the oil showed a well-marked fluorescence and possessed a slightly aromatic odour. The specific gravity at 60° Fahr. was 0·819.

The flashing point, determined by Sir Frederick Abel's apparatus, was 75° Fahr.

A measured quantity of the oil was subjected to fractional distillation with the following results:—

Temperature of Distillation.	Distillate.			
	Sp. Gr. at F.	Colour.	Per cent. by volume.	Per cent. by weight.
1st fraction distilling between 140° and 340° F.	0·753	Colourless	10	9·19
2nd „ „ „ 340° „ 360° „	0·770	„	10	9·39
3rd „ „ „ 360° „ 373° „	0·781	„	10	9·53
4th „ „ „ 373° „ 427° „	0·795	„	10	9·70
5th „ „ „ 427° „ 460° „	0·812	„	10	9·91
6th „ „ „ 460° „ 482° „	0·823	„	10	10·05
7th „ „ „ 482° „ 521° „	0·834	Faint yellow tinge.	10	10·18
8th „ „ „ 521° „ 563° „	0·849	Pale yellow.	10	10·36
9th „ „ „ 563° „ 594° „	0·861	Rich straw-yellow.	10	10·51
10th „ „ „ 594° and above.	...	Yellow	...	6·84
Residue: paraffin "scale" and "coke"	...	...	...	3·94
Loss	...	...	...	0·40
Total	...	...	...	100·00

The first three fractions flashed below 73° Fahr.; the remainder at higher temperatures. The ninth fraction, which was very mobile at the temperature of the laboratory (91° Fahr.), commenced to thicken appreciably on being cooled to 38° Fahr. and solidified at 27° Fahr. It will be noticed that the first nine fractions distilled over below 594°, showing that the heavier solid hydrocarbons are not present in large proportions. Of the remaining tenth, a part (6·84 per cent. by weight of the *original* quantity) consisted of a yellow oily liquid, which became of the consistence of *ghee* on cooling to 70° Fahr., on account of the solidification of the heavier paraffins. The remainder partially solidified in the condenser and partially remained in the retort. I did not consider it necessary to "coke" the portion left in the retort, as an estimation of the carbonaceous residue apart from the paraffin 'scale' would, in the present instance, offer very little information of use in forming an estimate of the economic value of the oil. The same remark applies also to the sample B., whose characters are described below, and in which also the solid hydrocarbons exist in very small quantities.

In estimating the proportion of *illuminating oil* I mixed 10 cubic centimetres of each of the first nine fractions, the mixture possessing a specific gravity of 0·808 at 60° Fahr. and flashing at 72° Fahr. After treatment with sulphuric acid, and subsequently with caustic soda to remove the impurities, a current of air was passed through the oil, whilst the flask was immersed in a warm water bath, to remove the very volatile naphthas introduced with the first fraction. The residue, which was almost "water white" and possessed a slight fluorescence, gave a flashing point of 76° Fahr. and a specific gravity of 0·810 at 60°. The removal of the naphthas, to raise the mixture to the legal limit of safety, was attended with a loss of 2·5 cubic centimetres. The burning oil of good quality may thus be set down at 87·5 per cent by volume (86·5 per cent. by weight) of the crude material.

The water accompanying this sample contained lime in solution with traces of iron and magnesia, and in combination with sulphuric, carbonic, and hydrochloric acids. It was neutral to litmus test.

Specimen B.

A clear, rich, straw-coloured liquid with a strongly marked fluorescence and slightly aromatic smell. Specific gravity at 60° Fahr.: 0·811. Flashing point (Abel's test): 64° Fahr.

Fractional distillation of 300 cubic centimetres gave the following results:—

Temperature of Distillation.	Distillate.			
	Sp. Gr. at 60 F.	Colour.	Per cent by volume.	Per cent by weight.
1st fraction distilling between 145° and 317° F.	0·741	...	10	9·13
2nd " " " 317° " 330° "	0·757	...	10	9·33
3rd " " " 330° " 382° "	0·777	...	10	9·58
4th " " " 382° " 424° "	0·793	...	10	9·77
Carried over				

Temperature of Distillation.	Distillate.			
	Sp. Gr. at 60 F.	Colour.	Per cent by volume.	Per cent by weight.
Brought forward .	...	...	...	...
5th fraction distilling between 424° and 448° F.	0·806	...	10	9·95
6th „ „ „ 448° „ 488° „	0·822	...	10	10·14
7th „ „ „ 488° „ 507° „	0·836	...	10	10·32
8th „ „ „ 507° „ 567° „	0·851	...	10	10·49
9th „ „ „ 567° and above	0·864	...	10	10·65
10th Above 567° F.	...	...	...	2·75
Residue: paraffin "scale" and "coke" . .	...	...	...	6·14
Loss	...	...	...	1·75
TOTAL .	...	...	...	100·00

In this specimen the temperature reached 600° Fahr. before the 9th fraction had completely distilled, and of the remainder 2·75 per cent. (of the *original* quantity) distilled over as a yellow, oily liquid which solidified on cooling to 55° Fahr. The remainder solidified at the temperature of the laboratory (90° F.)

To determine the proportion of illuminating oil 10 cubiccentimetres of each of the first nine fractions were mixed, the most volatile naphthas removed in the usual manner, and the residue purified with strong sulphuric acid and caustic soda. The product, measuring 84 cubic centimetres was a "water white" oil of specific gravity 0·810, flashing at 85° Fahr. The proportion of illuminating oil is thus 84 per cent. by *volume* (83·9 per cent. by weight). This result is perhaps slightly within the limit of production, as the removal of the naphthas was overdone by after-manipulation of the mixture at the high temperature of the laboratory (91° F.): the flashing point is thus raised well above the legal minimum and the specific gravity slightly above average American, but below some Russian kerosenes.

In comparing these two specimens it will be seen that *B* contains slightly large proportions of the very volatile hydrocarbons as well as the heavier and solid paraffins, whilst in *A* there is a greater predominance of the liquid compounds of intermediate density, which are of value for illuminating purposes. There is, therefore, a slightly greater waste in preparing *B* for the market, as the excess of very volatile compounds must be removed to bring the flashing point up to the legal minimum (73° F.) and the solid compounds must be eliminated to obtain a freely burning oil. Both samples are, however, of very high value, and there is no doubt that should they occur in sufficient quantity no foreign oil could compete against them.

These oils are evidently of the same kind as the sample examined by

Dr. C. J. H. Warden in September 1890, and in which he estimated a yield of at least 90 per-cent. of very superior, nearly "water white," illuminating oil.

In the following table the results obtained by Dr. Warden are compared with these which I have now obtained from Mr. LaTouche's specimens:—

Fractional distillation of Moghal Kot petroleums.

	I	II	
		A	B
1st fraction, 10 per cent.	·7557	·753	·741
2nd " "	·7685	·770	·757
3rd " "	·7802	·781	·777
4th " "	·7948	·795	·793
5th " "	·8077	·812	·806
6th " "	·8204	·823	·822
7th " "	·8367	·834	·836
8th " "	·8487	·849	·851
9th " "	·8596	·861	·864

I.—Procured by the Deputy Commissioner, Dera Ismail Khan, and examined by Dr. C. J. H. Warden (1890).

II.—Collected by Mr. T. H. D. LaTouche and examined by T. H. Holland (1892).

Referring now to the results of my examination of the Moghal Kot petroleum collected by Mr. Oldham,[1] it will be seen that in that specimen, whilst the liquid hydrocarbons predominate the very volatile constituents are absent. The first tenth obtained in the fractional distillation is seen to have a specific gravity of ·0782 whilst of the original crude material the flashing point was 128° Fahr. and specific gravity (at 60° F.) 0·831—all of which results are much higher than those obtained from the two specimens whose analyses I now report, and also of the specimen examined by Dr. Warden.

I find also that the remainder of Mr. Oldham's sample, which I have kept in the laboratory, is deeper in colour than either of those sent by Mr. LaTouche. From a comparison of the figures I should say that an oil like the former might easily be obtained from specimen A. (of LaTouche) by simple exposure to the open air in a warm climate, and this conclusion I find to be confirmed by artificially imitating the necessary conditions. I passed a current of air through 500 cubic centimetres of specimen A for twenty-four hours at a temperature varying within a few degrees of 90° F., and on examining the residue I found the flashing point had risen from 75° to 132° Fahr., and the density had increased from 0·819 to 0·835, whilst it had lost 14 per cent. of its original volume. On subjecting this residue

[1] *Records, Geological Survey of India*, Vol. XXIV (1891), p. 84.

to fractional distillation I obtained a series of distillates which agree very closely with those obtained from Mr. Oldham's sample, as will be seen by the following table :—

	Specific Gravity of Distillates.	
	I.	II.
1st fraction of 10 per cent.	·782	·784
2nd " " "	·794	·794
3rd " " "	803	·803
4th " " "	·813	·812
5th " " "	·823	·820
6th " " "	·835	·829
7th " " "	·847	·845
8th " " "	·857	·856
9th " " "	·869	·868

I.—*Sp. Gr.:* 0·831. *Flashing point:* 128° Fahr. Collected by Mr. R. D. Oldham (1891), *Records, Geological Survey of India*, Vol. XXIV., pp. 84 and 85.

II.—*Sp. Gr.:* 0·835. *Flashing point:* 132° Fahr. Residue after removal of naphthas from Specimen A, collected by Mr. T. H. D. LaTouche in the same locality.

These results show that artificial removal of the very volatile hydrocarbons from Mr. LaTouche's Sample *A* leaves a residue resembling in every respect the specimen previously collected by Mr. Oldham.

On a New, Fossil, Amber-like Resin *occurring in* Burma, *by* DR. OTTO HELM, *of* Danzig. (*Translated by* THOMAS H. HOLLAND, *Geological Survey of India.*)

Dr. Fritz Noetling, under orders of the Director of the Geological Survey of India, has sent me a piece of amber-like resin from Upper Burma. I have, as far as the small quantity of material would permit, made a chemical and physical examination of the specimen, and I hope to follow the publication of this preliminary investigation with a further contribution.

The fragment under examination is covered with a thin weathered crust of a brown colour. When broken it exhibits a shining, conchoidal fracture, with a greasy touch. The internal colour is dark-yellow, some parts being transparent and others sub-transparent, the latter being beclouded with organic matter finely disseminated through the substance of the resin. The specimen exhibits a fine blue

fluorescence. If light be sent into the interior with a convex glass lens, the cone of light appears of a golden yellow colour. In polarised light the same colour is exhibited, changing however, by revolution of the Nicols through 90°, to blue and orange.

The resin is as easy to cut, saw, and polish as the Baltic amber (Succinite); it is a little harder, however, than the latter, its hardness varying between 2·5 and 3.

Its specific gravity is 1.034.

As to the chemical constituents of this fossil resin I am not yet able, to give an ultimate analysis, as the piece in my possession exhibits no portion of perfectly clear colour, but is clouded throughout by finely disseminated particles. I have, nevertheless, made a dry distillation of the resin, and the results are extraordinarily interesting and different from those which other fossil resins give under like conditions. During the distillation, for which I used a glass retort, there first appeared a white vapour-cloud, which, on cooling, condensed to water-white drops; subsequently the vapour became tinged with yellow and condensed in thin oily streaks; ultimately the cloud was dissipated and thick oily drops flowed into the receiver. The distillate is a brownish yellow oil, with tarry consistency, of a peculiar burnt smell and an extremely small quantity of a watery liquid. I treated this liquid with hot water and filtered: it was water-white and gave an acid reaction with litmus-paper. On repeated distillation over a steam-bath a liquid distilled over and a yellowish residue remained behind, which I cleaned by solution in water with subsequent filtration and evaporation. The small quantity of crystals thus obtained I recognised, by well-known chemical reactions, to be pyrogallic acid, whilst the aqueous distillate contained formic acid. Succinic acid was not found in the products of distillation.

The resin contained 0·6 per cent. of ash, which was composed of iron-oxide, sulphuric acid, carbonic acid, and lime. I found a very small quantity (0·013 per cent.) of sulphur in combination with organic substances.

The fusion point of the resin cannot be determined, as before that point is reached it decomposes with evolution of a white aromatic vapour.

The resin proved to be very resistent against solvents:— Chloroform dissolves only 2·2 per cent. of it. Alcohol dissolves 0.8 per cent., the solution leaving behind, on drying, a black-brown resin. Ether dissolves 2.4 per cent., the solution leaving, on evaporation, a clear yellow resin. By oil of turpentine 18.5 per cent. was dissolved, whilst carbon bisulphide dissolved 4.6 per cent.

If the pulverised material is treated with concentrated sulphuric acid, the resin gradually dissolves, forming a solution of a red-brown colour, which blackens on heating. When the red-brown solution is treated with water a dirty white deposit separates out. Concentrated nitric acid at the ordinary temperature has little effect on the resin, but on heating the latter is changed into a yellow friable substance.

By friction the resin becomes electric and retains its electricity for some time.

From the foregoing investigation it seems that the Burmese resin differs from all the fossil resins with which I am up to the present acquainted; and I shall continue this research as soon as further specimens of clear colour are available.

Preliminary notice *on the* Triassic Deposits *of the* Salt Range.—By W. WAAGEN, PH.D., F.G.S.

For some years now I have been occupied with the study of the fossils that have been collected in the Salt-Range by different members of the Geological Survey staff, amongst them myself, as having found the greater part of those specimens that are characteristic of the higher divisions of the triassic strata of that country.

Though it is against my general custom to give a preliminary notice of the results of my investigations before the larger publication in the Palæontologia Indica can be ready for printing, in this case I feel obliged to do so on account of further explorations on a great scale which are now going on in the Himalaya, and which have for their object strata about equivalent to those that I have had the good luck to explore in the Salt-Range. It seems to me to be directly my duty to give to those indefatigable explorers in the Himalayas the benefit of my experiences in the Salt-Range, in order that they may be able to compare the Himalayan development of the Trias with that exposed in the Salt-Range.

The triassic strata of the Salt-Range were distinguished by Mr. Wynne under the general name of the Ceratite Beds—a name extremely appropriate for them—as nearly all the fossils contained in these strata consist of the remains of ammonoid shells all showing a "Ceratitic" development of their sutural lines. As regards the fossil forms that have been collected up to the present from these strata I must state that my studies have as yet been restricted chiefly to the Cephalopoda; and that amongst these only the "*Trachyostraca*" have been examined in detail. Thus I am only able to give their exact indications.

The Ceratite beds, as is shown in the first volume of my "Salt-Range Fossils," rest directly and without distinct unconformity on the topmost beds of the Productus Limestone, and are covered at their upper limit by the "Variegated Series" of Wynne. It must be remarked that the Ceratite beds do not comprehend all the strata that we in Europe generally comprise under the name of "Triassic Formation"; but that the Rhaetics are yet included in the Variegated Series, as they cannot be distinguished there from the Liassic Series, so that the top beds of the Ceratite strata cannot be more recent than "Carnic" at the utmost.

The lowest division of the Ceratite beds is formed by the "lower Ceratite Limestones: thinly bedded, light grey limestones, very hard, that loudly ring under the hammer. The fossils are mostly exposed on the bedding planes, and can be detached only with difficulty. Nearly all the Cephalopoda that occur in these strata belong to the genus *Gyronites* n. gen. W., a genus that has formerly been united by me wrongly with *Xenodiscus*, but which is distinct from that genus by a short body chamber, whilst *Xenodiscus* possesses a long one. *Gyronites* is most nearly related to *Meekoceras*. Besides *Gyronites* there are but very few other genera, and these represented only by single species. Of the *Trachyostraca* there is a single species of *Dinarites* present.

The next higher division is composed of the "Ceratite Marls." These are greenish-grey crumbling marls, with limestone concretions in which the fossils are contained. Small beds of limestone show a cone-in-cone structure. The Cephalopod fauna is perfectly different from that of the next lower division. The genus *Proptychites* n. g. (*Prop. lawrencianus*, Kon. sp.) predominates, *Gyronites* has

become much rarer, whilst *Meekoceras* increases enormously in numbers. Also here the *Trachyostraca* are represented by a single species of *Dinarites*.

Above the marls follows a thick series of yellow sandstones. These sandstones contain to all appearances three different faunas of Cephalopoda.

In the lower division of these sandstones there occur besides many species of *Meekoceras* and other allied genera of the *Leiostraca*, a number of typical forms of the *Trachyostraca*, *Dinarites* 2 sp., *Ceratites* 1 typical species, *Prionites* n. gen. (nearly allied to *Ceratites*, but the auxiliary lobes dissolved in very numerous small denticulations) 1 sp., *Celtite* 1 sp.

In the middle division a small gasteropod of the genus *Stachella* is very numerous, and therefore I have called these beds "Stachella beds." Here also many peculiar species of Cephalopoda occur, chiefly *Meekoceras* and allied genera. The genus *Flemingites* n. gen. makes here its first appearance, whilst the *Trachyostraca* are only represented by the genera *Dinarites* and *Celtites*.

In the upper division the fauna is not very rich but very characteristic. The genus *Flemingites* (*Flem. flemingianus* Kon. sp.) furnishes the most predominant forms. For this reason I have called these beds "Flemingites beds." *Meekoceras* and *Gyronites* are yet numerously represented; the genus *Proptychites* has got here its last representant.

Of the *Trachyostraca* the genera *Dinarites*, *Ceratites*, *Prionites*, and *Celtites* have been found, each of them, however, only represented by a single species. Besides these the first representant of the genus *Acrochordiceras* has been detected in these beds. The development of this form is, however, a very strange one, as the second lateral lobe is quite imperfect, and not distinctly developed. According to its sculpture this shell can, however, not be determined otherwise than as *Acrochordiceras*.

Above the Ceratite Sandstones a quite new fauna commences, and it can therefore, I think, not be much doubted that with these sandstones a greater period in the earth's history comes to a close. Thus probably the lower Trias must be terminated here, and all the beds that have been mentioned by me up to this horizon must be considered as the equivalents of the "Bunter Sandstone" of Europe. In Europe Cephalopoda are very rare in the Bunter, and only in the Alps there exists a bed in which the remains of Cephalopoda have more numerously been found. This represents probably the topmost division of the Bunter Sandstone only, whilst the lower divisions are all devoid of Cephalopoda shells. In India now there are not less less than five different faunas of Cephalopoda in the Bunter, and these commence already in the very lowest divisions of that formation so that apparently by the description of the Salt-Range faunas of the Bunt Sandstone a great gap in our knowledge of the triassic faunas will be filled up.

The division that follows next above the sandstones is composed again of limestones, and has received by me the name of "Upper Ceratite limestones." This division had been included by me in 1889 in the "Grey Bivalve limestones." The Cephalopod fauna contained in these Ceratite limestones is the richest one of all the triassic beds of the Salt-Range. Besides many species of *Leiostraca*, which have not yet been studied in detail, but which all appear to be more or less nearly related to *Meekoceras*, there are numerous forms of *Trachyostraca*, which are of the utmost interest, but of which no species is identical with a European one. Of the genus *Dinarites* there is only a single species, which has received by me the name of

Din. dimorphus W., and which exhibits so many points of affinity to *Din. glacialis* Mojs. from Siberia, that I cannot but consider the two as belonging to one and the same group of forms. Of the genus *Ceratites* there are not less than seven species, three of which belong to the " *Circumplicati*," two to the " *Nodosi*," one to the " *Subrobusti*," and one to the " *Nudi*." The new genus *Prionites* W. is represented by three species, and the genus *Balatonites* by one, somewhat doubtful form.

Of the family *Tropitidæ* the genus *Celtites* has furnished not less than eight species, which can be divided in two groups. One of them has got more squarish whorls, and resembles in this respect somewhat the group of *Celtites floriani*, Mojs.; the other has got more oval or roundish whorls, and thus resembles somewhat the group of *Celtites epolensis*, Mojs. The genus *Acrochordiceras* occurs in these limestones in typical forms and has furnished four species. Very nearly related to *Acrochordiceras*, but yet sufficiently distinct by the existence of enormous lateral thorns and a smooth external side, is a new genus, for which I intend to introduce the name of *Stephanites* W., and of which two species have been found.

A very remarkable fact relating to this fauna is also the frequent occurrence of the genus *Sibirites*, of which there are at least ten species. They are typically more or less nearly related to the forms described by Mojsisovics from Siberia.

This Cephalopod fauna, just described, is the last one that occurs in the triassic beds of the Salt-Range. Higher up only single stray specimens of Cephalopoda shells have been found.

The division that follows next higher in the sequence of strata is a series of hard grey limestones crowded with the remains of bivalve shells. I have therefore called these beds " Bivalve limestones." Of Cephalopoda there have been found in these beds some species of *Gyronites*, of *Meekoceras*, and a single form of *Dinarites*, besides some very characteristic species of *Nautilus*, which very much resemble European triassic shells. The same is the case with many of the bivalves, of which some *Myophoriæ* and *Gervilliæ* look as if collected in the German Muschelkalk.

I am inclined to consider the Upper Ceratite limestones as well as the Bivalve limestones as the equivalents of the Muschelkalk of Europe. So much is certain that with the latter again a great division comes to a close, and that the beds which follow yet higher in the series belong to another system of rocks.

The next higher division is composed of dolomitic strata which often show a rather indistinct bedding and attain a very considerable thickness. I have called these beds the " Dolomitic Group." This group of rocks is nearly devoid of organic remains. Some small internal casts of barely determinable bivalves and gasteropoda were the only fossils that I was able to detect. They are hardly sufficient to determine independently the age of these strata.

At last there follows above the Dolomitic group a small set of thinly bedded yellowish limestones, exposed in the west mostly, just at the base of the " Variegated Group." I shall introduce for them the designation of " Topmost limestones." They are crowded with fossils, chiefly bivalve shells, but also some Cephalopoda among them. The fossils can, however, only with the utmost difficulty be detached from the rock; and only a single species is in a fit condition to be deter-

mined exactly, but this is of very great interest. It is an ammonoid Cephalopoda shell, which on a first glance might be determined by everybody as a species of *Tropites*, but on a closer examination one finds that the sutural lines, as far as they can be observed, are much simpler than in the mentioned genus. There is only a single lateral lobe present, and this is only with very small denticulations: no ramifications whatever as in *Tropites* proper. Therefore, I must consider this form as belonging to a new genus, for which I shall introduce the name of *Pseudharpoceras*. Nevertheless it is of great interest to find here a form so nearly related to the genus *Tropites*, a genus which is so very characteristic of the Upper Trias of Europe.

I thus am led to parallelise the Dolomitic group as well as the topmost limestones with the Upper Trias (Keuper) of Europe. That in this Upper Trias the Rhaetic beds are not included has been remarked already above. They seem to be represented by a part of the Variegated series, as in some beds of this division species of plants, which occur also in the Rajmahal-beds, have been found.

It has been shown in former publications, that an overlap takes place at the base of the Variegated series, and thus the upper limit of the Ceratite formation is very distinctly marked. The formation must be terminated by the topmost limestones as distinguished by me. Whether then by the beds exposed in the Salt-Range the entire series of the upper triassic strata up to the Carnic group is represented, or whether there exists a greater gap, correspondig in time to the overlap, cannot be stated now.

The most peculiar feature then that results from all that has been stated up to the present consists in the circumstance that all the ammonoid Cephalopoda shells that have been found in the triassic beds of the Salt-Range show ceratitic, very rarely goniatitic, sutural lines, whilst the ammonitic development is completely absent. This constitutes a fundamental difference from nearly all the other triassic countries I had to describe already from the Permian of the Salt-Range a number of perfectly ammonitic forms, and in the next succeeding strata all such have absolutely disappeared.

In the Himalayas we have numbers of ammonitic forms in triassic beds, such as *Ptychites* and the like genera, but these are out of strata, which in their age most probably correspond to the Muschelkalk of Europe. In lower positions the Cephalopod fauna seems, according to Mr. Griesbach's indications, to be rather similar to that of the Salt-Range. It will now be one of the most important questions that will have to be solved by the exploration of the Himalaya, to state how far up in the series of strata the similarity to the Salt-Range extends, and in what relation the *Ptychites*-bearing rocks are to those containing part of the Salt-Range Ceratite fauna. Then also the question as to the definitive parallelisation of the Salt-Range strata with those of Europe can be borne out, and it will be possible to demonstrate whether my view, that the Upper Ceratite limestone must be considered as equivalent to part of the Muschelkalk of Europe, be correct or not.

If this view should prove to be correct this would go far to show conclusively that the Salt-Range triassic deposits belong to a triassic zoological province, which bears a certain similarity to the one that has been described in its contents from Siberia, but which would be absolutely different from that as developed in the Himalaya and the Alps.

ADDENDUM.

In connection with the preceding paper by Dr. W. Waagen I have thought it advisable to add the following translation of a paper read by Dr. Mojsisovics at the Academy of Sciences, Vienna, in May last, in which also the learned author gives a clear account of the origin and aim of the recent joint expendition which was sent to the Central Himalaya for the further collection of fossils from the Triassics between Milam and Niti. This Mission has now returned wtih a splendid and fully representative series of fossils, which are being dispatched to Vienna for study and description by our very highly esteemed and most specially versed Austrian *confrères* in Alpine Triassic geology, for whose engagement too on this work we have to thank a very constant and warm friend of the Survey, Professor Ed. Suess. Half of the collection will ultimately be returned to the Survey Museum. *Ed.*

Preliminary Remarks *on the* Cephalopoda *of the* Himalayan Trias.—By DR. EDM. VON. MOJSISOVICS.[1]

At the suggestion of C. L. Griesbach, who for some years past worked as Geologist on the Geological Survey of India, and who as such has earned much distinction by his travels and studies in the Himálaya and in Afghánistán, the Geological Survey of India consented to send the entire palæontological collections of the various Himálaya expeditions to Professor Ed. Suess in Vienna, with the request that this material might be described and worked out by Austrian specialists.

Invited by Professor Suess, I agreed to undertake the description of the Cephalopoda of the Trias, whilst Dr. Alex. Bittner will look after the description of the remaining fossils of this formation.

By far the larger portion of the Cephalopods of this collection bolongs to the lower beds of the Trias (concerning which we possess papers by Salter, Blanford, Stoliczka, Oppel, and Griesbach), and these demonstrate that in the Himálaya the Muschelkalk is represented by a fauna analagous to that of the Alpine Muschelkalk, whilst the Buntsandstein has yielded a peculiar fauna of its own.

However, almost completely unknown up to now were Cephalopods from the upper division of the Trias; they are represented in this collection by a few small suites of specimens found by Griesbach, which specimens are, however, of the greatest interest. It is unfortunate that the material is, quantitatively speaking, quite insufficient, if one is not contented with merely establishing the fact of the existence of a few species, but wishes to obtain a deeper insight into the composition of the different faunas and of the zoo-geographical relations of the latter to the arctic-pacific Trias province on the one hand, and to the European faunas of the triassic period on the other. For these reasons I declared, immediately after the receipt of the collections, that the material is insufficient for a monographic description of the Trias Cephalopods of the Himálaya, and I expressed at the same time the wish that, considering the great scientific interest which a more detailed knowledge of Himálayan Trias would possess, a special expedition might be organized and despatched for the purpose of making extensive collections at the more importan and promising localities.

[1] Sitzungsbericht d. Kais. Akademie d. Wissenschaften, Vienna. Math. Nat. Classe; Vol. CI, Abth. I, May 1892.

Thanks to the liberal response of the Director of the Geological Survey, who obtained for the purpose the necessary funds from the Indian Government, and owing to the liberality of our Academy, which voted a considerable sum of money out of the Boué fund; this expedition has now been made possible, and to Dr. C. Diener, who is in every respect fit to solve the task, has been entrusted the mission. Before this expedition leaves, it seems to me useful to set down our present knowledge of the subject, by giving a short sketch of the triassic cephalopods of the Himálayas as far as the available material permits, and by the aid of the stratigraphic data furnished by Griesbach.

I.—The alleged youngest cephalopod horizon represents approximately the zone of *Tropites subbullatus* of our Hallstatt limestones. The fauna consists chiefly of *Tropites* species, and shows quite a wonderful analogy with the forms of the Salzkammergut. The ammonites are unfortunately not very well preserved in the marly grey limestones, which impedes somewhat the determination and comparison of the same. The locality is situated close to the frontier of Tibet, seemingly in a stratigraphically very disturbed region.

Griesbach looked upon this horizon as lower lias according to the labels attached to his specimens, without, however, mentioning this fact in his fine volume on the "Geology of the Central Himálayas.[1]" I presume that the seeming similarity of the keeled *Tropites* species with *Arietites* has caused this mistake.[2]

Lower Lias is mentioned as occurring in normal position over rhaetic strata at other localities, the latter beds certainly agreeing in development with the Koessen beds of the Alps. It would be of the greatest importance to ascertain whether the *Tropites* limestone of Kalapani corresponds stratigraphically really with this Lower Lias, or, as may be more probable, it belongs to a lower horizon. In the first case, we would not be entitled to identify in future the complex of beds which lies below the *Tropites* beds with the rhaetic formation of Europe.

II.—A second Upper Trias Cephalopod horizon is found, according to Griesbach's report, below the Lower Rhaetic, which is correlated with our Dachsteinkalk and Hauptdolomite. At Rimkin Paiar were found a few small ammonites of the genera *Sibirites*, *Heraclites* and *Halorites*, which are related to forms in the Juvavian Hallstatt limestones; for which reason this fauna is of specially great interest, and it is most desirable to obtain further collections from this locality.

III.—A third cephalopod horizon of Upper triassic type is found at the base of Griesbach's Upper Trias, and is connected with dark *Daonella* limestone also of Upper Triassic type. The few specimens which we have out of this horizon belong to the genera *Arcestes*, *Entomoceras*, *Arpadites* and (?) *Trachyceras*.[3] Several of them remind me of species which occur in our Alps in the zone of *Tropites subbulatus*.

IV.—Whilst the Upper Triassic cephalopods here mentioned are known at present only from the regions of the Central Himalayas near the Tibetan frontier, it appears that the next horizon possesses a much wider horizontal distribution, for it is found not only in Kumaun, Niti, and the adjoining regions of Tibet, but occurs also

[1] Mem. Geol. Surv. Ind., Vol. XXIII.

[2] The label was written in the field, when the specimen was mistaken for Arietites, but the locality was later on recognized as Trias, and so recorded on the map. *Ed.*

[3] From this horizon seem to be derived a small portion of the fossils from the Niti Pass described by Salter in the "Palæontology of Niti."

in the second Triassic province of the Central Himalayas, that of Spiti, which is already known for some considerable time.

From this horizon, which may be looked upon as a homotaxial equivalent of the European Muschelkalk, are derived the fine series of fossils, collected by the Brothers Von Schlagintweit and described by Oppel, which are preserved in the Palaeontological Museum at Munich; also the fossil remains from Spiti described by Stoliczka, and part of the forms figured by Salter and Blanford in the "Palaeontology of Niti" which are now in the British Museum in London.

The collection entrusted to me for description comprises the entire material from this horizon, which was contained in the Calcutta Museum, including all the figured types of Stoliczka. This suite of fossils is far inferior to the Schlagintweit collection in the Munich Museum, but contains a few very valuable and interesting specimens.

Palaeontologically considered, the Muschelkalk of the Himalaya forms a connecting link between the "Arctic" and the "Mediterranean" Muschelkalk development, and I have already proposed for it the term "Indian Trias-Province." [1]

It should be prominently noted that a few genera occur in the Indian Muschelkalk which are only known in Upper Triassic strata in Europe.

Amongst them are—

Sagenites,	with the	species	*S. medleyanus* (Stol.)
Isculites,	"	"	*I. hauerinus* (Stol.)
Lobites,	"	"	*L. oldhamianus* (Stol.)
Cladiscites,	"	"	*Cl. indicus* (*Amm. gaytani*, Stol.)

V.—As the merit of the discovery of these three Upper Triassic Cephalopod horizons belongs to the indefatigable Griesbach, so also do we entirely owe our knowledge of the following cephalopod fauna, which underlie the Muschelkalk, to his investigations.

Within the upper division of a great thickness of beds immediately underlying the Muschelkalk, south-east of Muth in Spiti, a series of grey "Wellenkalk" like beds occur which contain a great number of casts of large ammonites, which remind one strongly of the great cephalopod fauna of the ceratite beds of the Salt Range, which W. Waagen is now describing.

Only, however, when further additions to this collection have been made, and Waagen's material has been worked out, will it be possible to decide whether this correlation is correct. Dr. Waagen looks upon the fauna of the ceratite beds of the Salt-Range as proving the latter to be homotaxially equivalent to the European Buntsandstein.[2]

VI.—At the base of the same series of beds are the *Otoceras* beds, discovered and exploited by Griesbach, with a cephalopod fauna of few genera, but great abundance of individuals. It is a true shell-limestone, chiefly formed of *Xenodiscus* specimens. Much rarer are *Meekoceras*, *Otoceras* and *Prosphingites*.[3]

In a somewhat lighter-coloured, less argillaceous rock, both in Spiti and in

[1] Arktische Trias faunen, Mém. de l'Académie imp. des sciences de St. Petersbourg. VII. Serie, T. XXXIII, No. 6, p. 153.

[2] I have before me a lower triassic fauna from the Bay of Ussuri near Vladivostock in Eastern Siberia, which has been absolutely unknown till now. I believe it to be homotaxially of Buntsandstein age. Muschelkalk also occurs there (Russkj Island) developed similarly to the Spitzbergen Trias, characterized by specimens of *Ptychites* and *Monophyllites*.

[3] Several species derived from this horizon, amongst them *Otoceras woodwardi*, have been described and figured by Griesbach in Rec. Geol. Surv. Ind., Vol. XIII, pp. 94 to 113.

Kumaun, occur forms which differ slightly from the species which are found in the typical Otoceras beds, and these possibly belong to a horizon which may be distinguishable from the lowest beds. Amongst the fossils of this upper horizon very evolute ceratites are conspicuous, which probably belong to the genus *Dinarites* although they remind one strongly of *Tirolites*. It appears that these beds are of great horizontal distribution, since several specimens of *Dinarites* in the collection have been brought from Banda in Kashmir.

As regards the probable age of these beds, which are immediately underlaid by Permian strata with *Producti*, it may be remarked here that the fossil contents bear the zoological character of a low Buntsandstein fauna. Goniatites are completely absent, and the ceratitic development of lobes prevails entirely. For this reason, the fauna appears still younger than the Permian species described by Abich from the Araxes defile near Julfa in Armenia, which contains besides *Goniatites*, also some species of *Otoceras*, although the latter are not so highly developed as the forms in the Indian Otoceras beds. It is therefore most probable that the Indian Otoceras beds form the base of the Buntsandstein, and are closest to the boundary of the Permian.

Since we also relegate the cephalopod fauna, mentioned in paragraph V, to the Buntsandstein ; it appears that the richest series of the Buntsandstein hitherto known is found within the Himalayan area : and that whilst in Europe and in Siberia the cephalopod-bearing beds begin far higher up, namely, immediately below the Muschelkalk[1]), in the Himalayas the entire series of strata of limestones and shales of homotaxially Buntsandstein age, shows a genuine pelagic character, and sediments, rich in cephalopods are found already at the base of the same.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 13.—ENDING 31ST OCTOBER 1892.

Director's Office, Calcutta, 31st October 1892.

The Director returned from privilege leave on the 24th of September. During his absence, Mr. Hughes, who officiated for him, spent most of the time on duty at Simla in immediate conference with the Revenue and Agricultural Department

[1] This is proved in the case of the Siberian Olenek beds by the high state of development of the principal cephalopod species.

The Diener Expedition, instituted by the Academy of Sciences of Vienna in communication with the Government of India, for the collection of a fuller and more representative series of fossils from the Triassic formation, as displayed in the Himalayan frontier country between Milam and Niti on the one side and the Thibet-Hundes on the other, has been brought to a successful conclusion. The party consisting of Dr. Diener who had been sent out from Vienna, and Messrs. Griesbach and Middlemiss of this Survey, broke up in the middle of October. Dr. Diener leaves Calcutta for Vienna on the 3rd November: a large collection of fossils which is fully and very duplicatively illustrative not only of the features and relations of the questions arising out of the more poorly represented series in the collections sent to Europe by the Survey last year for determination and description by Austrian specialists, follows Dr. Diener. A very happy result of the Mission is that the original survey of this Himalayan region by Mr. Griesbach has received complete confirmation. The further fossil evidence which was required to completely establish his three upper Triassic Cephalopod zones, and more especially his Indian-Muschelkalk horizon, with *Sagenites*, etc., and those of the *Dinarites* and the *Octoceras* beds, attributed to lower Triassic age, are reported to have been fully supplemented.

In the South of India, Mr. Holland took the opportunity, during the last month, of following up the series of ultra-basic rocks which he discovered last season in the Salem district. In the north-west direction, they occur intruding into the metamorphics of the Mysore State, and in places are accompanied by a development of magnesite and chalcedonic veins similar to those exposed on the well-known "Chalk" hills. The Corundum beds of the Hunsur taluq, which are associated with graphitic schists and are frequently interrupted by the above-mentioned igneous rocks, follow the general north-north-west and south-south-east strike of the crystalline schists of that area, and they may be traced from Singanamaranhalli in the south-east to Ramenhalli in the north-west; whilst, from the evidence of specimens which have been collected, it seems that the same beds extend in one direction into the Coimbatore district and in the opposite direction to the Uppinagadi taluq of the South Canara district—coinciding thus with the general direction of foliation of the metamorphic rocks. A many of these rocks are of considerable petrologica interest, Mr. Holland is preparing an account of their microscopic characters to accompany his field-notes. Amongst them we find a large series of hypersthene-bearing rocks varying in composition from hypersthene-microcline-granite to almost pure hypersthene-rocks. Various stages, also, in the decomposition of the Corundum, with its silicification and hydration, are represented amongst the specimens collected.

In a previous issue of these tri-monthly notes, No. 11, ending 30th April last, it was mentioned that Dr Noetling had been successful in unearthing a series of vertebrate fossils from the tertiary rocks near Yenangyoung. This collection is now being registered in the Museum of the Survey, and it turns out to be one of the finest displays of Siwalik forms which has been brought to light since the historic finds of Cautley and Falconer in the original Siwalik area. So far, Dr. Noetling has been able to discriminate the following:—? *Squaledon, sp.*; ? *Lutia, sp.*, *Anthracotherium silistrense*, Pent., *Anthracotherium*, cf. *hyopotamoides*, Lyd., *Cervus, sp.*, *Bubalus platyceros*, Lyd., *Boselaphus, sp.*, *Hipparion antelopinum*, Fal. and Caut., *Sus titan*, Lyd., *Hippopotamus iravadicus*, Lyd., *Rhinoceros* (*Acerotherium*) *iravadi-*

cus, Lyd., *Rhino. sivalensis*, Fal. and Caut., *Elephas* (*Stegodon*) *clifti*, Fal. and Caut., *Mastodon latidens*, Clift. *Avis, sp. nov.*, *Colossochelys atlas*, F. and C., *Emyda sivalensis*, Lyd., *Trionyx, sp.*, *Crocodilus sivalensis*, Lyd., *Garialis, cf. gangeticus*, Gmel., *Myliobates, sp.*, *Lamna, sp.*, *Cartharias, sp.*

Chipped flints were found in the *Hipparion antelopinum* bed, together with *Rhino. iravadicus*, *Rhino. sivalensis*, *Garialis gangeticus*, *Crocodilus*, sp., *Colossochelys atlas* and *Trionyx, sp.*

The officers of the Surey have been disposed for the camping season as below, and most of them are now at the scene of their operations :—

Rewa.—Theo. W. H. Hughes, Superintendent; F. H. Smith, Assistant Superintendent; Kishen Singh, Sub-Assistant.

Baluchistan.—C. L. Griesbach, C.I.E., Superintendent.

Assam.—R. D. Oldham, Superintendent.

Lower Burma.—P. N. Bose, Deputy Superintendent; P. N. Datta, Assistant Superintendent.

Upper Burma.—Fritz Nöetling, Palæontologist.

Salt-Range Coal.—Tom. D. LaTouche, Deputy Superintendent; W. B. D. Edwards, Assistant Superintendent.

Hazara.—C. S. Middlemiss, Deputy Superintendent; Hira Lal, Sub-Assistant.

Head-quarters.—The Director; and T. H. Holland, Assistant Superintendent.

It is intended that Mr. Hughes shall visit Mergui early next year, in view of the coal exploitation on the great Tenassarim river, which is about to be undertaken by Mr. Bose. Mr. Oldham, at present on leave, will keep touch with head-quarters until the forthcoming Manual of the Geology of India is completely passed for Press. Mr. Holland is engaged, in addition to his other duties, in lecturing on Geology at the Presidency College. He will avail himself of every opportunity for continuing his mineral exploration in the Madras Presidency.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October, 1892.

Substance.	For whom.	Result.
Two specimens of ferruginous quartz, from Mysore mines assayed for gold.	T. W. H. HUGHES, Geological Survey of India.	

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October, 1892—continued.

Substance.	For whom.	Result.
Three specimens of coal, and one of iron pyrites, from Burma.	P. N. DATTA, Geological Survey of India.	See the coal analyses below.
Four specimens of Amalgam	J. DRIVER, Managing Agent, Kalianpur-Behar Gold Mining Co., Ld., Calcutta.	Assayed for gold and silver.
Four specimens; quartz, clay, etc., for gold; and 6 specimens for tin, from Burma.	P. N. BOSE, Geological Survey of India.	(1) Quartz, from "Oleingwin, old pits." (2) Quartz, stained with oxide of iron from "Shwe Dong, near Tavoy." (3) Quartzite, with specks of iron pyrites, from "Manoroon." (4) Ferruginous clay, from "Shwe Dong, near Tavoy." Contain no gold.

Result for the three specimens of coal and one of iron pyrites, from Burma (printed sideways in the Result column):

	"Outcrop, ½ miles east by south of Pakhoung Village." Quantity received, 17¼ oz.	*"Chaumojoo stream, seam (b)." Quantity received. 12 oz.*	*"Chaumojoo stream, seam (c)" Quantity received. 27 oz.*
Moisture	8·40	6·20	7·10
Volatile matter	34·40	38·54	34·02
Fixed carbon	49·52	47·70	40·82
Ash	7·68	7·56	18·00
	100·00	100·00	100·00
	Does not cake. Ash, reddish brown.	Does not cake. Ash, reddish grey.	Does not cake. Ash, reddish grey.

Nodular iron pyrites, from Sagaing District, Burma. Quantity received 9¼ oz. Contains 29·6 per cent. of sulphur.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October, 1892—continued.

Substance.	For whom.	Result.
		(1) Washed sand, chiefly tourmaline, from "Frathan, head-waters of the Lenya River." Contains tin. (2) Washed sand, from "Manoroon." Contains a trace of tin. (3) Washed sand, from "Shwe Chang Myetta." Contains tin. (4) Decomposed granite, from "Granite Hill Mines, Inner Bokpyn." Contains no tin. (5) Red micaceous sandstone, from "Hill Mines, Maliwoon." Contains no tin. (6) Specimen from "near Indeorza." = Wolframite, with quartz.
Coal found while digging a well at Village Chattri, about 42 miles from Bikanir, at a depth of about 240 feet from the surface; seam about 5 feet thick.	C. S. BAYLEY, C.S., Political Agent, Bikanir.	*Quantity received 12¾ oz.* Moisture . . . 9·04 Volatile matter . . 30·30 Fixed carbon . . 14·42 Ash . . . . 46·24 100·00 Does not cake. Ash-pale gray.
Quartz and calc-spar, with iron pyrites, from Chota Nagpur.	J. YATES, MACKILLICAN & Co., Bengal Gold and Silver Mining Co., Calcutta.	Assayed for gold.
Two specimens of rocks, from Madras, for silica percentage.	THOMAS H. HOLLAND, Geological Survey of India.	*No. I, 470, from N. W. of Kanjamalai, 1 mile from Sitheswarankovil.* Contains 54·46 per cent. silica (SiO_2). *No.* $\frac{8}{754}$, *from Pallavaram.* Contains 47·79 per cent. silica (SiO_2).
Amber, from the amber mines, Upper Burma.	F. NÖETLING, Geological Survey of India.	No. I, 359, sp. gr. 1·037. " I, 362, " 1·046. " I, 363, " 1·039. " I, 366, " 1·036. " I, 367, " 1·033. " I, 367, " 1·037. " I, 367, " 1·035. " I, 367, " 1·035. " I, 370, " 1·042. " I, 371, " 1·036. " I, 371, " 1·037.
Coal and clay, from Kalaba-Toung, about 12 miles from Kyaukphyu.	A. LEIDS, Deputy Commissioner, Kyaukphyu.	*Coal. Quantity received, 66lbs.* Moisture . . 3·02 Volatile matter . 53·12 Fixed carbon . 29·34 Ash . . . 14·52 100·00 Cakes strongly. Ash, red.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September, and October 1892 – concluded.

Substance.	For whom.	Result.
Crystalline limestone, found in Sikkim.	J. C. WHITE, Political Agent, Sikkim.	*Clay. Quantity received, 7lbs.* Fused completely at a reddish-white heat; will not answer as a fire-clay. Contains 21·00 per cent. of insoluble matter, consisting of sand, etc., the rest (79 per cent.) being carbonate of lime, with a trace of iron and alumina.

Notifications by the Government of India and the Geological Survey of India during the months of August, September, and October 1892, published in the "Gazette of India," *Parts I and II.—Leave.*

Department.	No. of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	REMARKS.
Revenue and Agricultural Department.	$\frac{1639}{166}$, dated 3rd August 1892.	P. N. DATTA, Assistant Superintendent, Geological Survey.	Privilege	26th Aug. 1892.	18th Oct. 1892.	
Ditto .	$\frac{1779}{174}$, dated 16th August 1892.	H. B. W. GARRICK, Artist, Geological Survey.	Do. .	20th Aug. 1892.	10th Oct. 1892.	
Geological Survey Depertment.	1205, dated 26th August 1892.	R. D. OLDHAM, Superintendent, Geological Survey.	Do. .	7th Oct. 1892.	...	

Annual Increments to graded Officers sanctioned by the Government of India during August, September, and October 1892.

Name of officer.	From	To	With effect from	No. and date of sanction.	REMARKS.
	R	R a. p.			
P. N. DATTA, Assistant Superintendent, Geological Survey.	300	313 5 4	1st July 1892.	Revenue and Agricultural Department No. $\frac{1612}{161}$, dated 30th July 1892.	

Annual Increments to graded Officers sanctioned by the Government of India during August, September, and October 1892—concluded.

Name of officer.	From	To	With effect from	No. and date of sanction.	REMARKS.
	R	R a. p.			
F. H. SMITH, Assistant Superintendent, Geological Survey.	350	380 0 0	1st August 1892.	Revenue and Agricultural Department No. $\frac{1737}{172}$, dated 13th August 1892.	
T. H. HOLLAND, Assistant Superintendent, Geological Survey.	380	410 0 0	1st September 1892.	Revenue and Agricultural Department No. $\frac{2040}{185}$, dated 13th September 1892.	
C. L. GRIESBACH, Superintendent, Geological Survey.	900	950 0 0	1st August 1892.	Revenue and Agricultural Department No. $\frac{2051}{184}$, dated 13th September 1892.	
FRITZ NÖETLING, Palæontologist, Geological Survey.	660	700 0 0	1st October 1892.	Revenue and Agricultural Department No. $\frac{2385}{202}$, dated 22nd October 1892.	

Postal and Telegraphic Addresses of Officers.

Name of Officer.	Postal address.	Nearest Telegraph Office.
T. W. H. HUGHES	Mirzapur	Mirzapur.
C. L. GRIESBACH	Quetta	Quetta.
R. D. OLDHAM	Calcutta	Calcutta.
P. N. BOSE	Mergui	Tavoy.
T. H. D. LATOUCHE	Haranpur	Haranpur.
C. S. MIDDLEMISS	Abbottabad	Abbottabad.
W. B. D. EDWARDS	Haranpur	Haranpur.
P. N. DATTA	Mergui	Tavoy.
F. NÖETLING	Calcutta	Calcutta.
HIRA LAL	Abbottabad	Abbottabad.
KISHEN SINGH	Mirzapur	Mirzapur.

DONATIONS TO THE MUSEUM.

FROM 1ST AUGUST TO 31ST OCTOBER 1892.

A miscellaneous collection of minerals, from Cornwall.

PRESENTED BY CHARLES VON DER HILLEN, 53, CHOWRINGHEE, CALCUTTA.

A specimen of auriferous quartz, from the Rajgeer Range, about 4 miles from the eastern end, Behar; and a string of beads made from rock crystals, at Nana, about 8 miles south of Behar.

PRESENTED BY C. PURDY, KALYANPUR.

Fragment of a molar of Elephas sp., from the Godavari River.

PRESENTED BY T. VANSTAVERN, DOWLAISHWERAM.

ADDITIONS TO THE LIBRARY.

FROM 1ST JULY TO 30TH SEPTEMBER 1892.

Titles of Books. — *Donors.*

ANDRÉ, *George G.*—A Practical Treatise on Coal-mining. Vols. I and II. 4° London, 1888.

BALL, *Sir Robert.*—The Cause of an Ice Age. 8° London, 1891.

BECKER, *George F.*—Geology of the Quicksilver Deposits of the Pacific Slope. 4° Washington, 1888.

REVENUE AND AGRICULTURAL DEPARTMENT.

BENEDIKT, *Dr. R.*, and KNECHT, *E.*—The Chemistry of the Coal-Tar Colours. 8° London, 1889.

BLAKE, *J. F.*—Annals of British Geology for 1890. 8° London, 1891.

BONNEY, *Prof. T. G.*—The Year-Book of Science for 1891. 8° London, 1892.

BREZINA, *Aristides.*—Explanation of the principles of Crystallography and Crystallophysics. 8° P. Washington, 1874.

BRONN'S Klassen und Ordnungen des Thier-Reichs:—

Band II, Abth. II., lief. 6-8.
„ II, „ III., „ 13-16.
„ III, lief. 1.
„ IV, „ 21-23.
„ V, Abth. II., lief. 32-34.
„ VI, „ V, „ 37-39.

8° Leipzig, 1892.

CASSINO, *S. E.*—The Scientists' International Directory, containing the names, addresses, special departments of study, and of Professional and Amateur Naturalists, Chemists, Physicists, Astronomers, &c., &c. 8° Boston, 1892.

CONSTABLE, *Archibald.*—Travels in the Mogul Empire by Francois Bernier. A.D. 1656-1668. 8° Westminster, 1891.

DAVIES, *D. C.*—A Treatise on Earthy and other Minerals and Mining. 8° London, 1892.

FISHER, *Rev. Osmond.*—Physics of the Earth's Crust. 8° London, 1889.

FORBES, *David.*—Report on the progress of the Iron and Steel Industries in Foreign Countries. 8° P. Newcastle-upon-Tyne, 1876.

GEIKIE, *A.*—Elementary Lessons in Physical Geography. 8° London, 1892.

Titles of Books. *Donors.*

GOUIN, *François.*—The Art of Teaching and Studying Languages. 8° London, 1892.

HARRISON, *W. Jerome.*—Elementary Text-Book of Geology. 8° London, 1889.

HARRISON, *W. Jerome*, and WAKEFIELD, *R.*—Earth Knowledge. Parts I and II. London, 1891.

HOLLAND, *T. H.*—Preliminary Report on the Iron-Ores and Iron Industries of the Salem District. 8° P. Calcutta, 1892. THE AUTHOR.

KING, *C. W.*—The Natural History of Gems or Decorative Stones. 8° London, 1867.

KOLBE, *Dr. H.*—A short text-book of Inorganic Chemistry. 8° London, 1892.

LEPSIUS, *Richard.*—Geologie von Deutschland und den angrenzenden Gebieten. Band I, lief 3. 8° Stuttgart, 1892.

LITTLEHALES, *G. W.*—The average form of Isolated Submarine peaks, and the interval which should obtain between soundings taken to disclose the character of the bottom of the Ocean. 8° P. Washington, 1890.
REVENUE AND AGRICULTURAL DEPARTMENT.

MARCOU, *Jules.*—The Geological map of the United States and the United States Geological Survey. 8° P. Cambridge, Mass, 1892.
THE AUTHOR.

MERRILL, *George, P.*—Stones for Building and Decoration. 8° New York, 1891.

MILLS, *F. W.*—Photography applied to the microscope. 8° London, 1891.

MILNE, *John*, and BURTON, *W. K.*—The Great Earthquake of Japan, 1891. 2nd Edition. Fol. Yokohama, 1892.

NEWBERRY, *John S.*—Fossil Fishes and Fossil Plants of New Jersey and Connecticut Valley. 8° Washington, 1888.
REVENUE AND AGRICULTURAL DEPARTMENT.

" The Paleozoic Fishes of North America. 4° Washington, 1889.
REVENUE AND AGRICULTURAL DEPARTMENT.

Norwegian North Atlantic Expedition, 1876—1878. Zoology, Crinoida and Echinida, by D. C. Danielssen. 4° Christiania, 1892. THE COMMITTEE.

Paléontologie Française Terrains Tertiaires Éocéne Echinides. Tome II, liv. 26. 8° Paris, 1892.

PAMELY, *Caleb.*—The Colliery Manager's Hand-book. 8° London, 1891.

PHILIPS' Handy Volume Atlas of London. 8° London, 1891.

ROSCOE, *Sir H. E.*, and SCHORLEMMER, *C.*—A treatise on Chemistry. Vol. III, part 6. 8° London, 1892.

SADTLER, *Samuel P.*—A Hand-book of Industrial Organic Chemistry. 8° Philadelphia, 1892.

SIEMENS, *C. W.*—On Puddling Iron. 8° P. London, 1868.

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